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Musculoskeletal Injuries in Young Footballers and Associated Risk Factors

Dissertação elaborada com vista à obtenção do Grau de Mestre na Especialidade de Ciências da Fisioterapia

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RESUMO

Enquadramento: O Futebol é associado a elevada incidência de lesões, que podem implicar custos para a saúde e performance de atletas e clubes.

Objetivos: Analisar as características da lesão, prevalência, incidência, e identificar Fatores de Risco para lesões músculo-esqueléticas numa Academia de jovens futebolistas durante uma época, usando as definições de lesão "*Medical Attention*" (MAI) e "*Time-loss*" (TLI).

Metodologia: Estudo epidemiológico descritivo, de desenho prospetivo em coorte que seguiu as recomendações do *Consensus Statement on Injury Definitions and Data Collection Procedures in Studies of Football (Soccer) Injuries* da F-MARC. Amostra constituída por 19 jovens futebolistas (17,05±0,52 anos).

Resultados: A prevalência das MAI foi 94,74% (8,16 Lesões/Jogador) e das TLI foi 63,16% (1,58 Lesões/Jogador). A Incidência de Lesão Total (ILT) das MAI foi 44,54 Lesões/1000HE. A Incidência de Lesão em Jogos (ILJ) foi seis vezes maior que em treino (ILTr). Para as TLI, a ILT foi 8,62 Lesões/1000HE. A ILJ foi até sete vezes maior que a ILTr. Três quartos das lesões ocorreram nos membros inferiores. As MAI afetaram a Perna / Tendão de Aquiles, Joelho e Coxa. As TLI afetaram principalmente a Coxa e o Tornozelo. Hematoma / Contusão (MAI: 44,50%; TLI: 26,67%), lesão Muscular (MAI: 22,60%; TLI: 23,33%) e lesão Articular (MAI: 12,90%; TLI: 16,67%) foram os diagnósticos mais comuns. Mais de dois terços das lesões foram traumáticas e cerca de 20% deveram-se a *Foul Play*. A Taxa de Recidiva foi de 10,97% (MAI) e 23,33% (TLI). O *Injury Burden* Total foi 211,77 Dias de Ausência/1000HE, e foi pelo menos cinco vezes mais elevado em jogos que em treino. Lesões em jogo foram mais numerosas e mais graves.

Conclusões: O risco de lesão foi elevado durante a época, com 18 em 19 jogadores a sofrer pelo menos uma lesão. Elevada exposição às exigências físicas e mentais do futebol podem predispor o jogador para lesão. Estratégias de fair play e prevenção de lesões devem ser enfatizadas pelas equipas técnica e médica.

Palavras-chave: Epidemiologia; fatores de risco; incidência de lesão; futebol; sistemas de registo de lesões; lesões no futebol; jovem futebolista; lesões músculo-esqueléticas; lesão atenção médica; lesão tempo de paragem.

ABSTRACT

Background: Association Football is associated with high incidence of injuries that could affect both players and clubs in terms of cost for health and performance.

Aims: Analyse injury characteristics, prevalence, incidence, and identify associated Risk Factors for musculoskeletal injuries in a youth Football Academy during one season, using both Medical Attention (MAI) and Time-loss injury (TLI) definitions.

Methods: Descriptive epidemiological study with a prospective, cohort design that followed the recommendations of the F-MARC's Consensus Statement on Injury Definitions and Data Collection Procedures in Studies of Football (Soccer) Injuries. Sample formed by 19 young footballers (17.05±0.52 years).

Results: MAI prevalence was 94.74% (8.16 Injuries/Player) and TLI prevalence was 63.16% (1.58 Injuries/Player). MAI Total II was 44.54 Injuries/1000EH. Match II was more than six times higher than training's. For TLI, Total II was 8.62 Injuries/1000EH. II was up to almost seven times higher in matches than training. Three quarters of injuries occurred in the lower limbs. MAI were most seen in the Lower Leg / Achilles Tendon, Knee and Thigh. TLI mainly affected the Thigh and Ankle. Haematoma / Contusion (MAI: 44.50%; TLI: 26.67%), Muscle (MAI: 22.60%; TLI: 23.33%) and Joint injuries (MAI: 12.90%; TLI: 16.67%) were the most common diagnosis. More than two thirds of injuries were traumatic and around 20% were due to Foul Play. Rate of recurrence was 10.97% (MAI) and 23.33% (TLI). Total Injury Burden was 211.77 Days of absence/1000EH, and was more than five times higher for matches than for training. Match injuries were more and more severe.

Conclusions: Risk of injury was high throughout the season, with 18 out of 19 players sustaining at least one injury. High exposure to the physical and mental demands of football may predispose players to injury. Development of fair play and injury prevention strategies should be emphasized by coaching and medical staffs.

Keywords: Epidemiology; risk factors; injury incidence; association football; injury-reporting system; football injuries; youth football; musculoskeletal injuries; medical attention injuries; time-loss injuries.

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GLOSSARY OF ABBREVIATIONS

%	Per cent / Percentage
<	Lower
>	Higher
=	Equal
≠	Different / Difference
+	Plus
±	More or less
1GAT	First Generation Artificial Turf
2GAT	Second Generation Artificial Turf
3G	Third Generation
3GAT	Third Generation Artificial Turf
4GAT	Fourth Generation Artificial Turf
ACL	Anterior Cruciate Ligament
AT	Artificial Turf
ATFL	Anterior Talofibular Ligament
BMI	Body Mass Index
cm	Centimetre
e.g.	Example given
EH	Exposure Hours
Ex.	Example
F-MARC	FIFA's Medical Assessment and Research Centre
FIFA	Fédération International de Football Association
f_{imp}	Peak Impact
FP	Foul Play
GK	Goalkeeper
h	Hour
HE	Horas de Exposição
ILJ	Incidência de Lesão em Jogo
ILT	Incidência de Lesão Total
ILTr	Incidência de Lesão em Treino
II	Injury Incidence
IP	Injury Prevalence
IR	Injury Rate
Kg	Kilograms
Kg/m^2	Kilograms per square meter
m	Meter
MAI	Medical Attention Injury
MCL	Medial Collateral Ligament
MH	Match Hours
MRI	Magnetic Resonance Imaging
N	Amount / Number of cases
NFL	National Football League
NG	Natural Grass
No.	Number
OP	Outfield Player
OSICS	Orchard Sports Injury Classification System
RF	Risk Factor
ROM	Range of Motion
SD	Standard Deviation
SPSS®	Statistical Package for the Social Sciences
t_{con}	Time of Contact
TH	Training Hours
TLI	Time-loss Injury
U-19	Under-19
UEFA	Union of European Football Associations
v_{app}	Approach velocity
vs.	Versus
y	Year

1. INTRODUCTION

Association Football, commonly known as Football or Soccer, is associated with high incidence of injuries that could occur during training sessions and matches. These injuries are more prevalent in the ankle and knee joints and in the thigh and calf muscles. [1-3]

Football Academies are institutions where young players try to develop their skills in order to become elite footballers. This skill acquisition is what's affected when injury causes absence (up to 6% of the season) from training and competitive sessions. Injuries affect players (costs associated with individual health, career and skill acquisition during an important phase of development for young players) and clubs (costs associated with injury diagnosis and management, and decreased team performance and morale) both financially and socio-economically. [4] In professional clubs, injury has a different impact, measured by the missed competitive matches and its' effect on the performance of the team or player's wages. [5]

These injury consequences should be addressed and controlled, particularly for young athletes, who are at a higher risk of injury because of their immature systems (both physically and physiologically) and individualised development. This is manageable by introducing injury prevention programs that intend to emphasize the importance of the player's health and safety. But for these prevention programs to really work it is important to adapt them to reality. For this we need to understand the incidence, prevalence and severity of injuries of youth football and the risk factors (RF) that really affect injury characteristics. [5-7] This can be properly answered by epidemiological studies, using an adequate, replicable and comparable methodology. These should help football clubs and academies to not only adhere to health and safety legislation but also provide them with valuable information (e.g.: injury incidence and pattern, RF, consequences of injury) to allow them to create and implement preventive strategies. [5] After all, only an uninjured athlete can perform at his / her best. [8]

In order to implement an effective intervention / prevention plan in sports / Football injuries it is important to [7]:

I. Collect information;
II. Identify and describe the findings;
III. Implement injury prevention strategies;
IV. Reassess to verify the effects of the implemented strategies.

This study aims to answer to the first two points described above, which are, to collect, identify and describe information related with injury occurrence in a Football Academy during one season, to serve as a basis for posterior intervention-based studies.

2. LITERATURE REVIEW

Physical activity in sports may help athletes to improve and / or maintain their health and fitness, compete, or simply socialize and relax. [9] Association Football is highlighted as a safe activity with few harmful consequences for a large spectrum of the population. [10]

Fédération International de Football Association (FIFA) has 208 member associations from all around the world and a history of more than one hundred years (since 1904). More than 300 million people are active and registered footballers, referees, coaches, administrators, medical and paramedical personnel. F-MARC (FIFA's Medical Assessment and Research Centre) was established in 1994. Their objective is to protect players' health by helping to reduce / prevent football injuries by providing adequate scientific evidence. [11]

According to F-MARC, an injury is any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time-loss from football activities. [12]

Union of European Football Associations (UEFA) reports the existence of 20 million licensed footballers, just in Europe. [13] As a world recognized team sport, football is important for the development of physical activity and fitness characteristics of the growing number of young players. [14] This also represents an increase in football-related injuries and the consequent economic burden. [1, 15]

Association Football is characterized by different levels of participation, from recreational levels to international competitions. [15] Football was found to be the single sport with the highest overall incidence of injury in the Olympic Games of Beijing 2008. The risk of sustaining an injury (including time-loss injuries) was highest in football, with more than 50% being player-contact injuries. [16] Among United States High School athletes (including volleyball, basketball, wrestling, baseball), both male and female football incurred 10.5% and 15.0% of all injuries, respectively. Injury Rate (IR) was higher comparing with other sports. Competition's severe IR was higher than training's, and more common among girls. Most common injured anatomical regions (knee, 38.9%; ankle, 16.0%; and head / face, 11.2%) and diagnosis (fracture, 30.3%; complete ligament sprain, 20.3%; and incomplete ligament sprain, 13.6%) are often presented. [17]

When comparing football (both professional and amateur) with other sports, it is visible that football has a higher risk of injury (for both acute and chronic injuries). This often results in the interruption of practice and absence from play by the player, affecting team performance, morale and results. First choice players that don't play because of injury may result in important costs for the club (e.g.: reduced player match attendance, decreased prize money from low league position or even exiting a competition earlier). In academy settings, this absence time also results in missed development. Injured players can be in rehabilitation up to several months or, in some situations, develop loss of function and chronic pain resulting in decreased or inexistent participation in sport. [5, 8, 17-20]

Investigation needs to be done and preventive measures emphasized and implemented in order to prevent this. Epidemiological studies of football injuries should help clubs complying with current health and safety legislation. This should also be used to learn the causes of injury in professional football. The studies are scarce for young footballers, thus needing development and implementation of specific investigation protocols. [5, 8, 17-20]

2.1. Epidemiology of Football Injuries

When analysing epidemiological studies on football injuries it's easy to realize that results vary substantially. This is mainly due to injury definition heterogeneity, population characteristics and study design. [21] This decreases the validity of direct comparison between studies. [15] It is important to study injury patterns and characteristics, but it is even more important to understand that comparison between studies is difficult and needs to be done carefully, if we want to retrieve valid conclusions from them.

It has been shown already that football shows higher IR (5.1 vs. 2.1-2.8 Injuries/1000 Exposure Hours (EH)) and absence from play due to injury than other sports. Both acute and overuse injuries are more reported in the lower extremity as a consequence of the specific loading patterns of football. [22]

Sports-related injuries in primary health care (General Practitioners) were studied in the Netherlands. Injury incidence and prevalence was calculated to be 23.7 and 27.8 in 1000 patients per year, respectively. Football injuries were the most common. Lower extremity was affected in 76.8% of the situations. Seventy-five per cent of injuries had an acute onset. [23]

Football injuries are more prevalent in the ankle (16-29%) and knee (7-36%) joints and in the thigh and calf muscles. Upper leg (9-22%), lower leg (5-6%) and groin / torso (5%) are less affected. Only 3-12% of injuries are in the upper extremity. Head / facial injuries (including concussion) account for 3% of total. Regarding type of injury, sprains, strains and contusions are the most prevalent. An elite male football player would sustain one performance-limiting injury per year. [1, 21]

The mechanism of football injuries is usually trauma during contact with another player (12-28%) (e.g.: tackle or being tackled, head the ball) and / or overuse in 9-34% of the cases. Twenty-six to fifty-nine per cent of injuries occur in non-contact situations (e.g.: run, twist / turn, shoot, land). Most of them are minor, affecting the lower extremities and would lead to a maximum of 7 days of absence from play. Foul play (FP) accounted for up to 28% of all injuries and recurrences (same type and location) for 20-25%. [1, 21]

Much investigation has been done regarding epidemiological analysis of IR and associated RF for specific football injuries, from amateur to top-level athletes. Studies on injuries to the head [24], ankle [25], hamstring [26, 27], groin [28, 29], Anterior Cruciate Ligament (ACL) [30], patellar tendinopathy [31], and fractures [32] are just some examples. Below, some of these studies will be analysed.

2.1.1. Injury Reporting Studies

Several studies have been developed with the objective of describing the injury pattern and characteristics in football clubs during competitive seasons or championships.

Hawkins et al [19] and Woods et al [20, 33, 34] followed, during two seasons, 91 of the 92 football clubs (2376 players, aged 17 to 35+) from professional English football leagues (Premier league, 1st, 2nd and 3rd Divisions). An injury was recorded if it was acquired during training or competition and prevented the player from participating in normal training or competition for more than 48 hours (day of injury not included). Regarding injury severity, dependent on player absence, they could be slight (2-3 days), minor (4-7 days), moderate (1-4 weeks) or major (>4 weeks). Injuries with less than 2 days of absence (or none) were not considered, as it would be difficult to report due to working practices in the clubs. Players' exposure to matches and training was not recorded. [19]

Each club sustained, per season, a mean of 39.1 injuries. In average, 1.3 injuries occurred per player per season. Every injury caused the player to lose a mean of 24.2 days (4.0 matches, in average). [19] Younger footballers (17-25 years) were at higher risk of injury than older / more experienced ones (26-35+ years). Knowledge on how to deal with physical and mental factors during this phase is suggested as an influencing factor. [20]

Eighty-seven per cent of injuries affected the lower extremities (thigh, with 67% being posterior muscle strains and 14% anterior; ankle, 11%; and knee, showing ligament sprains in 39% of cases). Slight injuries were 10% of total, 45% were classified as moderate and both minor and major counted 23% of total. [19]

An IR peak was seen in the preseason training (July) and in the first month of competitive season (August), declining after those periods. [19, 20] Preseason injuries accounted for 17% of total with an average IR of 0.2 per player per preseason. Preseason's most common injury locations were the thigh (23%), knee (17%), and ankle. Muscle strains (19%), fractures (15%), ligament sprains (13%) and meniscal tears were the most common major injuries. Moderate injuries were mostly strains (42%), sprains (25%) and tendinopathies (8%). Sprains affected mostly the ankle (59%, of which 74% and 21% affected the lateral and medial ligament complexes, respectively) and knee (30%) joints. Lower leg injuries, such as muscle strains / rupture (37%) and tendon related injuries (e.g.: Achilles related injuries, 32%) were more prevalent in preseason, probably due to training characteristics (increased intensity and duration). Preseason muscle strains occurred in the rectus femoris muscle (29%; because of its participation in running and shooting activities), adductor longus (12%) and biceps femoris (21%). Non-contact mechanisms of injury (e.g.: running, 25%) accounted for 68% of cases. Injuries resulting from contact (e.g.: contusion, tissue bruising) were less prevalent. More slight (13%) and minor (27%) injuries and less severe injuries (61%) were recorded in the preseason when compared with the competitive season (9%, 22% and 69%, respectively). Overuse injuries were more prevalent (3%) in preseason. It is suggested that starting to train, suddenly, on a new surface allowing no adaptation from the athlete may explain those findings. [20]

During the competitive season muscle strains affected the biceps femoris (11%), adductor longus (15%) and rectus femoris (14%) muscles. [20] Match injuries account for two thirds (63%) of all recorded injuries. Strains (mainly muscular), sprains and contusions were the most common injury types (69%). Contusions mainly occur in matches, perhaps because of the surrounding competitive atmosphere. Higher strain proportion in training is not fully explained and may be a cause of concern. [19]

Player-to-player / ball contact injuries occurred in 38% of the cases. Fifty-eight per cent had a non-contact mechanism of injury. Recurrences were documented as 7% of all injuries, with 66% being lower extremity strains (48%) or sprains (18%) and resulted in more time of absence (25.1 days) compared with the initial injury (19.1 days). [19]

F-MARC has developed important investigation for elite professional football. These "UEFA injury studies" allow a broader, complete and methodologically adequate understanding of football injuries.

The UEFA injury study [35] reports Injury Incidence (II) and pattern in professional football. Seven seasons were recorded (2001-2008) following recent injury definition recommendations [12, 36]. II was found to be of 8.0 Injuries/1000EH. Injury risk remained unchanged through the course of the study. In fact, in an elite team of 25 players it is expected that 50 injuries would occur per season, with minor severity in half of the cases (<7 days of absence from play) and severe in eight or nine situations (>4 weeks of absence). [35]

Twenty-eight per cent of all injuries were overuse injuries, peaking in the preseason period. Traumatic injuries were more common during the rest of the season (matches: 81%; training: 59%). Traumatic injuries, strains, sprains and contusions tended to occur in the final part of both halves. Fatigue is thought to be one of the causes, when combined with a decrease in high-intensity runs and technical performance. [35]

Fifty-seven per cent of injuries occurred during matches and 87% affected lower extremities (thigh, knee, ankle and hip / groin). The most common injury types were muscle strains (mainly hamstring strains), ligament sprains and contusions. Adductor pain / strain, ankle sprains, and medial collateral ligament (MCL) injuries accounted for 9%, 7% and 5% of all injuries, respectively. [35]

The incidence of hamstring strains was low in preseason and three times higher in the competitive season. This high risk might be related with the high intensity of professional football, mainly during matches. Head injuries (such as concussions, facial fractures, lacerations and eye injuries) occurred in 2% of cases. Concussions might go underreported if the symptoms are unrecognized by the medical staff or if the athlete doesn't report voluntarily his symptoms. [35]

Recurrences accounted for only 12% of total, and resulted in longer absence from play. This is lower than shown in similar studies (that show recurrence rates from 22% to 30%) [37-40]. This could be due to the existing medical support, personalized rehabilitation and use of more specific and modern functional tests that better prepare the athlete for playing. [35]

Hagglund et al, in another UEFA injury study, found that 35% of all recorded injuries during 9 football seasons (2001-2010) were low extremity muscle injuries affecting the adductors, hamstrings, quadriceps and calves. Overuse injuries (34%) affected mainly the adductors.

Recurrences accounted for 27% of total (hamstrings, 30%; adductors, 29%; quadriceps, 21%; and calf, 21%). [41]

In the 2010 FIFA World Cup, an injury study aimed to analyse the incidence and characteristics of injuries and illnesses. The entire 32 finalist teams (736 players) participated with an overall response rate of 97.4%. The incidence of match injuries and Time-loss Injuries (TLI) decreased when compared with the three proceeding World Cups (from 2.3 to 2.7 injuries per match). In matches, an average of 61.1 Injuries/1000 Match Hours (MH) was verified (52.7% resulted in absence of 1-3 days). In training, a total of 104 injuries occurred (7.9 Injuries/1000 Training Hours (TH)), and the incidence of TLI was of 4.4 Injuries/1000TH (57.4% of total; 43.6% with 1-3 days of absence). [42]

Injuries remained similar to previous World Cups in location and type, but less knee and more thigh injuries tended to happen. In matches, lower extremity injuries accounted for 73.6% of the total, followed by the head / neck (10.4%), upper extremity (9.6%) and trunk (6.4%). The most common diagnosis were contusions of the thigh and lower leg and thigh strains for matches, and ankle sprains and thigh strains in training. Injury episodes increased progressively during the course of the match. Fewer injuries due to FP were recorded (23% in 2010 versus 61% in 2006). [42]

Match injuries resulted from non-contact (35.5%) and contact (64.5%) situations. Training, in the other hand, revealed overuse (24.0%), recurrence (11.5%), non-contact trauma (23.1%) and player contact (40.4%) as causes of injury. Non-contact injuries proportionally increased (from 27% in 2002 to 35.5% in 2010) when compared with contact-injuries (64.5% in 2010). Overload of players (congested football calendar) is indicated as a possible cause. It is also suggested that these results are a consequence of the evolution of football as a health-enhancing leisure activity. Better results could be reached with the application of prevention programs (e.g.: FIFA 11+), referee education and fair-play attitudes by coaches and players. [42]

A survey of football injuries during twelve FIFA tournaments recorded injury data using report forms. This methodology proved adequate due to its' 84% average response rate. The ankle (17%) and thigh (16%) were the most affected body parts. Regarding diagnosis, contusion (59%) was the most frequent, followed by strains (10%) and sprains (10%). Only 14% of injuries were non-contact and approximately 34% resulted from FP. Discrepancies in injury pattern and characteristics were found between Under-17 and Under-20 tournaments. It was hypothesized that physical maturity (strength), ambition and experience play a role in this matter. [43]

Walden et al studied injuries in 11 professional clubs during one season (2001-2002) of the UEFA's Champions League. Eighty-five per cent of the players sustained at least one injury. Of these, 85% affected the lower extremity. Thighs, knees and ankles were the most injured body locations. Major injuries (>28 days of absence) were mostly due to trauma (87%). No differences between preseason and competitive season were present. [13]

Thigh (61%) and groin (21%) were the most common locations for strains. The most common injury subtype was thigh strain (16%; 65% affecting the hamstring muscles). Most sprains occurred in the ankles (51%) and knees (39%). FP injuries accounted for 23% of all match injuries (contusions, 46%; sprains, 37%) and 27% of total were overuse injuries (e.g.: low back pain, Achilles tendinopathy, adductor related groin pain, patellar tendinopathy). Overuse accounted for 61% of all the recurrences (15% of all injuries). Absence times were similar for the recurrence and the index injury. Injuries acquired during national team play accounted for 4% of the total. But, although match exposure was higher for players that played in national teams, the risk of injury didn't increase for them. [13]

Werner et al only considered TLI. Hip / groin injuries accounted for 12-16% of all injuries. These values are consistent between seasons showing that this is not an increasing problem in professional football. Apart from this, hip / groin injuries result in more than a week of absence in more than 50% of cases (moderate injuries, with 8-28 days of absence, 41%; severe injuries, with >28 days of absence, 12%). Adductor injury (64%), hip flexor / iliopsoas injury (8%), unspecified groin pain (5%) and sportsman's hernia (4%) were the most common diagnosis. Fifteen per cent were recurrences (other studies refer 31-50% of hip / groin reinjuries) and caused more absence from play than the index injury. Prevention measures would help decreasing absence from play. Factors like player and staff awareness (e.g.: don't play with groin pain) would be important. [44]

Dupont et al, over two seasons, documented an overall IR of 8.9 Injuries/1000EH (training: 3.7 Injuries/1000TH; matches: 48.7 Injuries/1000MH) affecting the ankle and knee joints, and thigh and calf muscles. Both overuse (76%) and traumatic events were recorded as causes of injury. Eleven per cent of injuries were considered major injuries (>28 days of absence). [4]

Azubuike et al conducted an epidemiological study of injuries in 7 clubs in Nigeria (from amateur to professional) for one season. An injury prevalence of 81.6% was found and lower extremity involvement occurred in 77.5% of cases. Most affected body parts were the ankle (25%), knee (20.1%) and thigh (13.2%). The most common injury types were sprains (33.3%), strains (13.2%) and lacerations (6.9%). Traumatic (86.8%), contact related (62.3%) and match injuries (46.1%) were the most common. Recurrences occurred in 38.8% of cases and 28.9% of all injuries were classified as moderate (8-28 days of absence). [18]

A 15-year (1993 to 2007) prospective epidemiological study analysed match injuries in the Japan Professional Football League (J-League). Only injuries that resulted in a minimum of 7 days of football absence were recorded, and only 3 levels of injury severity (mild, moderate and severe) were considered. Injury circumstances reported by team physicians included cause of injury (contact / FP) and time of injury. All matches were played in natural grass turf. [45]

These operational definitions are not in accordance with recent recommendations [12], which makes comparison difficult. Their conclusions, though, are also interesting as evidence shows that injuries that result in absence from play from 0 to 7 days may comprise from 50% to 80% of all injuries. [38, 45-48]

Over 15 years 2947 injuries (21 recurrences) were recorded. Due to injury definition the total IR (19.11 to 24.37 / 1000 player hours) was approximately half the rate usually reported by other authors. This rate had a gradual decrease over the years with no change on injury pattern. FP-related injuries showed a gradual decrease tendency over the years. The most common injuries (66.5%) were in the lower extremity (ankle, knee and thigh). Most common diagnosis were sprains, contusions and muscle strains. Concussions accounted for 8.7% of the cases (all by contact play and FP in 40% of the cases) and a high incidence of lacerations was recorded when compared with previous studies. The number of recurrences was small, and some were recorded as recurrences of previous non-recordable injuries. This shows that only significant recurrences were considered and that, in some cases, minor injuries are a RF for future significant injury. [45]

Arnason et al found hamstring strains, groin strains, knee sprains and ankle sprains as the most frequent injury types in elite footballers in Iceland (46% of matches from 9 out of 10 teams from Icelandic Elite Football League were analysed). [49]

Another UEFA injury study studied national teams' injury characteristics in 12 UEFA European Championships (2006-2008). Only TLI were considered but both training and match exposure was recorded. [47]

The main findings, similar for mature and young footballers, were that match II increased with age and that a quarter of all match unavailability was caused by training injuries (20%). This shows the impact of such injuries on team performance and the importance of preventive strategies. Incidence of severe injuries was higher than the reported by elite professional clubs. IR was found to be 0.9 injuries per match. The highest II was found in the men's Under-21 and women's Under-19 (U-19) tournaments. [47]

Most common injuries were muscle strains (27%), contusions (26%) and ligament sprains (25%). Traumatic injuries (player-to-player contact, 54%; non-contact, 20%) accounted for 76% of all injuries. Seventeen per cent of injuries were due to FP and 9% were recurrences (e.g.: groin muscle strain, thigh strains, and ankle sprains). Recurrences tend to cause longer absence than index injuries. Mean injury absence was 13.4 ± 26.3 days. This low recurrence rate supports the assumption that injured players are not selected for international duty squads in the first place. [47]

Babwah studied a national team's injury incidence during three international tournaments over a 14-month period. Both Medical Attention (MAI) and Time-loss injury (TLI) definitions were used. Overall incidence, training and match IR were 26.5, 14.6 and 86.6 Injuries/1000EH, respectively. These rates were two to three times higher than the ones reported in professional leagues. Forty per cent of injuries were caused by contact and 6% were classified as severe (>28 days of absence). In their opinion, these results occur because of training characteristics (higher intensity and conditioning for players), increased competition among players (for team selection) and use of better recording systems that allow proper consideration of minor injuries by the team physician. [50]

Turkish national football team injury incidence, mechanisms, severity and anatomic locations were studied over a period of six consecutive seasons (training sessions, and friendly, official, and tournaments matches). Operational definitions followed the consensus statement on injury definitions developed by F-MARC. II was 60.6 and 8.08 Injuries/1000EH for matches and training sessions, respectively. Lower extremity accounted for 80.6% of all injuries and the most common injury locations (e.g.: thigh, 25%; knee, 15.7%; leg / ankle, 11.1%; head / face / groin, 8.3%; toes / lower back, 6.5%; neck / foot, 2.8%; and fingers, 1.9%) and types (e.g.: contusion, 32.4%; strain, 30.6%; sprain, 21.3%; tendon injury and laceration / abrasion, 5.6%; ligament rupture, 3.8%; and concussion, 3.7%) were analysed. Thirty-seven per cent of injuries recovered in 1-3 days. A higher incidence of thigh injuries was emphasized by the authors, probably due to inadequate training techniques and rehabilitation. [51]

Chomiak et al analysed severe injuries (both traumatic and overuse) in footballers of different ages (14-42 years) and skill levels (local to first league teams). Severe injuries accounted for 16.5% of all injuries, and were caused by trauma (81.5%) or overuse (18.5%). Fifty-nine per cent occurred in matches and 24% were recurrences. Contact (46%) and non-contact (54%) injuries were recorded. FP (e.g.: tackling and kicking) occurred in 31% of the situations. The most common diagnosis was joint sprain (30%), fracture (16%), muscle strain (15%), ligament rupture (12%), meniscal tear and contusion (8%). Lower extremity sustained 74.2% of the injuries and upper extremity 14.4%. Knee (29%), ankle (19%) and spine (9%) were the most affected body locations. [52]

Muscle injuries are the most common type of injury in professional football. Ekstrand et al studied 51 professional football teams over up to 9 seasons, and concluded that in a team of 25 players, it is expected that 15 Muscle injuries will occur, per season, with 2 weeks of absence for each injury. Almost one third (31%) of all injuries were muscular. Contusions, hematomas, tendon ruptures, and chronic tendinopathies were excluded though. [53]

Ninety-two per cent of all Muscle injuries affect the four major muscle groups of the lower extremity (hamstrings, 37%; adductors, 23%; quadriceps, 19%; and calf muscles, 13%). Hamstring injury accounted for 12% of all injuries and 60% of quadriceps strains occurred in the dominant leg (preferred kicking leg). Two thirds of Muscle injuries were traumatic with acute onset. They occurred in noncontact situations in more than 90% of cases. Only 5% were due to FP. In what concerns absence time from matches and training, 58% of cases resulted in more than 1 week of absence. Severe injuries (11%) caused more than 4 weeks of absence. Quadriceps strains were the type of injury that caused the longer absences (17 days). This time-loss can affect team performance. Preventive measures should be implemented, but for that further investigation on RF and mechanisms of injury should be done. [53]

Muscle injury recurrence rate was 16%, resulting in longer absence time than the index injury (17.8 ± 25.2 vs. 13.8 ± 17.0 days). The median days lost were 9 and 10 days, respectively. No significant difference in IR was found between the most common injury locations (adductors, 18%; hamstrings, 16%; quadriceps, 17%; and calves, 13%). [53]

Woods et al calculated that five hamstring strains (resulting in absence of 90 days of training and 15 matches) would occur per club per season. The most affected muscle was the biceps femoris (53%). The main mechanism of injury was “running” (57%), although specific variables (such as speed, nature and phase of run) were not recorded. Injury episodes occurred during matches (67%) and training (32%). Twelve per cent of cases were recurrences. [34]

Carling et al documented a hamstring strain recurrence rate of 23.4% in a professional football club. It was the most common recurrent injury and incidence was 1.32 strain recurrences per 1000EH with half of the players incurring at least one recurrence. This rate was higher for matches and attackers (that show high instantaneous speed demands when the agonist concentric muscle action cannot be withstand by antagonist eccentric strength), and peaked in May (38.6% of all episodes). Each muscle strain recurrence lead to an average absence of 3 days and 0.4 matches per player per season. A total of 85 working days and 11 matches were lost per season, emphasizing the importance of preventive strategies. [27]

Woods et al documented that ankle sprains accounted for 67% of all ankle injuries, 77% of those involving the lateral ligament complex (Anterior Talofibular Ligament (ATFL) involved in 73% of cases). Medial ankle ligaments were affected in 14% of cases, which is in accordance with the demands of football (e.g.: kicking with inside foot, receive tackles). Only 4% of the sprains showed anterior and posterior tibiofibular ligament and interosseous membrane involvement. Player-to-player contact (59%) mechanism of injury (e.g.: tackling, 54%) was reported more often than non-contact (e.g.: landing, twisting and turning, running). Only for goalkeepers non-contact mechanism of injury was more prevalent (e.g.: landing, 36%; twisting / turning, 21%; diving, 10%). Absence from play lasted for less than one month in 83% of cases. This may suggest that both low severity of ankle sprains and short rehabilitation period may lead to reinjury (9%). Most injuries (66%) occurred during matches (48% on the last third of both halves) and 44% were sustained in the first 3 months of the season. [33]

Up to 15% of all ankle sprains in young athletes are syndesmotic (7%) or medial (5%). These specific types of ankle sprains show high IR in football when compared with other sports. Frequent player-to-player contact and cutting manoeuvres are thought to play a role on this. Syndesmotic ankle sprains result in more time-loss (13.9 days, in average) than both lateral and medial ankle sprains. [54, 55]

First-time ankle sprains' IR is reported to be less than 1 per 1000 days of exposure to sport. Age, gender and type of competition seem to have no effect on this injury. Care should be taken as this study involved different types of sport (which is associated with female IR). [56]

Few studies on female footballers exist. Girls tend to suffer more knee injuries (2.8 higher risk of ACL injury and concussions, in a training session) when compared with male players. Regarding ACL injuries, they usually result from valgus and / or hyperextension of the knee during cutting, landing or turning. This gender imbalance is thought to be due to hormonal influences, anatomic differences, ligament size and laxity, and dissimilar neuromuscular patterns. [1, 21, 57]

Junge et al studied female match IR and circumstances in top-level female international tournaments (from 1999 to 2006). Both MAI and TLI were recorded as suggested by Fuller et al [12]. They showed that II in elite female players is higher in internal tournaments than during the season. Interestingly overall II remains low when compared with elite male footballers. [58]

Lower extremity (65%), head / neck (18%), trunk (9%) and upper extremity (8%) were the most prevalent injury locations, and specifically the ankle (24%), head (16%), thigh (12%), knee (11%) and lower leg (11%). The most diagnosed injuries were contusions (45%) and ankle sprains (16%). Head injuries and concussions were more prevalent in female than in male footballers. Different diagnostic parameters between male and female footballers have been suggested to explain this. Severe knee injuries (including ACL tears) are also a concern for female players. Most injuries were caused by player-to-player contact (84%) but only 29% was due to FP. [58]

If only TLI are considered, ankle (30%), knee (15%), thigh (14%) and head (11%) were the most affected body locations. Ankle sprain (25%), knee sprain / ligament rupture (11%), thigh contusion (8%) and concussion (7%) were the most prevalent diagnosis. [58]

Among United States High School athletes, girls sustained more knee (49.7%) and ligament sprain (31.4%) injuries and the boys, more fractures (42.0%). It is suggested that these differences might relate with gender-related differences in body size, speed, strength, and intensity of play. [17]

2.2. Youth Football

In Portugal, 547 000 players are registered in the Portuguese Football Federation. Up to 20% of them are children and adolescents. [10] Participation in sports and recreational activities allows young athletes to increase fitness, motor coordination and socialization skills. The existent risk of injury will predispose young players to sustain more and more severe acute and overuse injuries. Intensive training in younger ages or multiple sport participation exposes the athletes to more risky situations. [59, 60]

It is important to promote adequate athletic activities, because although it helps some young players to get healthier (by decreasing Body Mass Index (BMI), increasing cardiovascular fitness, promoting good habits) it may also cause time losing medical issues if athletic involvement is too intense. This means that many young athletes' quality of life might be affected by unexamined and unintended injury consequences. [59]

Young athletes are different from mature adult athletes both physically and physiologically. This may lead young players to be more injury prone. Young athletes can be "school-age children" (5-12 years), "adolescents" (13-18 years) and "young adults" (18-24 years). Each age-related stage has its own particularities. Children have larger surface area to mass ratio, larger heads proportionally (may lead to head injuries), small body size (that can affect the proper use of protective equipment). Growth plates (physes) are still open in children and, theoretically, they can close early if certain activities are performed. More susceptible to stress, they might be related with the occurrence of overuse injuries. Adequate control of complex motor skills needed for certain sports are not present until after puberty. [8, 60]

Pre-pubescent athletes do not acclimate as well as older people to heat due to their higher threshold for sweating and lower sweat rate. For that reason they are prone to heat injuries. Acute blunt traumas result in fewer injuries because of less strength and speed involved. With softer and porous bones, fractures are likely to occur in the growth plates. [60]

Adolescent athletes are more likely to be injured than younger children. This happens because greater mass, speed and therefore power (consequence of circulating androgens) are combined with teenage impulsiveness and recklessness. [8, 60] Some authors even suggest that training / match intensity in 16-18 year olds is similar to those of adults, which would result in similar injury patterns. [52]

Overall football II has been described to range from 2.3 Injuries/1000TH to 14.8 Injuries/1000MH. [15] Young children are affected by mainly upper extremity (e.g.: hand, wrist, shoulder) and head injuries, and older players tend to sustain lower extremity injuries (e.g.: ankle, knee, hamstrings). [60]

Lower extremity was the most affected in youth football (e.g.: knee, ankle). Upper extremity is affected in up to 20% of situations. Contusions (25-47%), sprains (20-35%), muscle strains (8.25%) and fractures / dislocations (3-12%) are the most common injury types in youth football. Avulsion fracture prevalence in the pelvis (e.g.: ischial tuberosity) is 17.7%. Head injuries in youth football have low incidence. [15]

Acute onset of injuries occurs in most of the cases. Majority of youth football injuries (70-80%) are minor or moderate, not resulting in significant absence from play. Half of injuries result from player-to-player contact. Youth players tend to get injured during tackles, while professional players sustain more injuries during running. [15]

Frish et al documented that the main acute injuries in youth sports are sprains (27-48%), strains, fractures, dislocations and contusions. [8] Overuse injuries account for 10-34% of all reported injuries in youth football. [8] Specifically for football, IR and locations for sprains, strains (17-53%; mostly at the groin, thigh, calf and back regions), fractures (2-37%; mostly at the wrist, foot and ankle regions), dislocations (0.3-30%) and concussions (0.36 Injuries/1000EH) have been described. [8] Generally, contusions (up to 50%) and strains lead the type of recorded injuries. Muscle strains are more common in older players, while apophysis strains or apophysitis occur mainly in early adolescence. [8, 60]

Apophysitis are injuries caused by repetitive motion and overuse during periods of rapid growth. The most common apophysitis are Osgood-Schlatter Disease in the insertion of the patellar tendon on the tibial tubercle (between ages 11-15 years) and Sever's Disease in the insertion of the Achilles tendon and plantar fascia on the calcaneus (7-10 years). These might account for up to 5% of injuries. [8, 60] Patellar Femoral Pain Syndrome is a chronic, dull and aching knee without known aetiology (although its cause is multifactorial). Young athletes should also be assessed for hip problems when this condition is presented with an insidious onset, as Slipped Capital Femoral Epiphysis is also prevalent in pre and early-adolescents. [60]

Ankle and knee sprains are common in youth football because of its' running and pivoting movements, sharp cutting manoeuvres, stopping and starting movements and jumps and landings on one foot. [8] Lateral ankle sprains have the highest rate (up to 1.50 Injuries/1000EH). In young players with open physes, Salter-Harris type I and II fractures can occur. [60] Knee sprains are more incident in female footballers when compared with males (0.72 vs. 0.14 Injuries/1000EH). [8] ACL injuries also show a high rate, especially in female (adolescent) athletes, in non-contact circumstances involving deceleration or change of direction forces, such as described in football. This high incidence of ACL injuries is alarming. [15, 60]

Much investigation has been done regarding epidemiological analysis of IR and RF for youth football injuries, from amateur to top-level athletes. Studies on injuries to the ankle [61, 62], muscle injuries [1, 27] are just some examples. Below, some of these studies will be analysed.

2.2.1. Injury Reporting studies in Youth Football

Epidemiological studies focusing youth football injuries are scarce and sometimes their methodology is inadequate or not comparable.

Football academies show a lower II in training (48%) and competition (52%) when compared with professional clubs. [5]

Brito et al [10] studied 28 youth amateur football teams for one whole season. A sample of 674 players (aged 12-19 years) was followed prospectively from the preseason to the end of competitive season (43 weeks approximately). Injury and exposure information was recorded using forms filled by the physiotherapists and / or coaches. Study definitions followed the consensus statement on injury definitions and data collection procedures (soccer) by Fuller et al [12].

More moderate injuries across all age groups were reported. This could have happen because of injury definition (time-loss). That is, minor injuries might have gone unreported and / or underestimated because players didn't need to stop completely from training, or medical attention was not necessary. [10] U-19's was the age group that sustained the highest incidence of severe injuries. Most severe injuries peaked on preseason and after midseason break. [1, 10]

Injuries mainly affected the lower limbs. The thigh and knee were the most affected body locations during preseason. Muscle strains and ligament sprains were the most diagnosed types of injury. Muscle injuries accounted for 30% of the total and knee injuries (including ACL injuries) for no more than 12% (less than previously reported). Joint sprains (mainly affecting the ankle) were most reported in older players as a consequence of trauma (97%) or collision or tackles with opponents (63%). Contact injuries (between players, ground, ball or goalpost) represented 57% of all injuries. Traumatic injuries were less severe than overuse injuries. For older players, higher level of aggressiveness and type of play are pointed as possible causes. [10]

In accordance with previous evidence, variations of II across the whole season exist. Injuries peak after the preseason training period (training injuries - September; match injuries – October) and after midseason break. [10]

Price et al [5] studied injuries sustained in 38 English youth football academies (9-19 years) over the period of two competitive seasons. On this prospective epidemiological study, both match and training injuries were recorded. Although injury definition was in accordance with previous studies, only injuries with a minimum of 2 days of absence (excluding the day of injury) were considered. Injuries from international duty were included. [5]

Data from 29 football academies showed an average IR of 0.40 per player per season. Injuries occurred evenly between matches (50.4%) and training (48.7%). The majority of injuries were strains (31%), sprains (20%), contusions (8%) or tissue bruising (7%). Fewer contusions are reported in training but the opposite occurs for muscle strains. Ninety per cent of them involved the lower limbs (thigh, knee, ankle, groin or lower leg), and 54% the dominant side. [5]

In the thigh, strain was the main injury type (79%; of these, 43% were on the anterior thigh, and 57% on the posterior thigh), probably due to the muscles' characteristics in the young player (incomplete development and limited shock absorption) during technical actions (e.g.: kicking, acceleration) and its' function as a stabilizer of the pelvis. [5]

Eighteen per cent of injuries affected the knee, mainly the MCL (85%) and the ankle presented similar results (19% of total; of these, 83% to the ATFL). Because of its participation in tackles, jumping, kicking, landing and turning, the dominant side was the most affected. [5]

Five per cent of the injuries were Osgood-Schlatter Disease (peak in the Under-13 and Under-14) and Sever's Disease related (peak in the Under-11). The pubertal growth spurt in males around this age appears to play a role in this injury behaviour. This should allow the implementation of effective prevention plans. [5]

Only 3% of recurrences were recorded (mostly strains and sprains). Recurrent strains affected mainly the quadriceps (35%), hamstrings (33%) and hip adductors (20%); sprains involved the ATFL (78%) and the MCL (20%). [5]

Stracciolini et al compared paediatric II between children (5-12 years) and adolescents (13-17 years). Lower extremity was affected in 30.2% of cases. Age was an important factor, with children sustaining more upper extremity injuries (traumatic and bony – fractures), and adolescents more head, chest, hip / pelvis, and spine injuries. Most common lower extremity injuries were due to overuse (e.g.: Osgood-Schlatter Disease, Sever apophysitis). ACL injuries accounted for 9.4% of total. Overuse and traumatic injuries were divided equally among children. Adolescent sustained more soft tissue injuries. Children were diagnosed mostly with Osteocondritis Dissecans, fractures (e.g.: physeal fractures), and apophysitis. [59]

The National Collegiate Athletic Association Injury Surveillance System monitored football injuries for 15 years (1988-2003). Although IR remained relatively stable, a non-significant decreasing trend suggests that preventive strategies are having an effect. Lower extremity was affected in more than two thirds of the cases (e.g.: ankle, knee, thigh, and hip). The most common diagnosis was ankle sprain, contusion and strain to the lower extremity. Twenty-four per cent of ankle sprains were recurrences. Player-to-player contact (61%) was the main cause of match injuries leading to injuries such as concussions, contusions, and knee injuries. Side slide tackles were identified as an important cause of injuries (e.g.: tibial and fibular fractures) and it was verified that some injuries result from violent play that does not constitute FP. Prevention strategies (e.g.: use of protective equipment / shin guards) and rules of the game should be re-evaluated and emphasized. [63]

A study with young footballers (8-16 years) over 5 seasons revealed that muscle injuries are the main reason for training absence. Thirteen per cent of all injuries affected the thigh complex (more than 97% of muscle injuries affected the quadriceps, hamstrings and adductors) and resulted in a median of 13 days of absence from training. It was found that the quadriceps muscle is the one at higher risk, although severe injuries (17%; absence >28 days) tend to affect mostly the hamstrings complex. Recurrences (27%) were more likely to occur in players with age 16 years, midfielders and players with initial hamstring injury. Time off from initial and reinjury were similar. [64]

Analysis of adolescent soccer injuries from North America has found a consistent IR of about 5 Injuries/1000EH. Muscle strains were found to make up 18% of all injuries, and the thigh / upper leg complex represented 13% of all injuries by anatomic site. [65]

High School football injuries in the United States were studied using an internet-based sports-related injury surveillance system. An injury was reportable if it required medical attention (by athletic trainer or physician) and if it resulted in absence from play. [65]

Match IR (60.1%) was higher than training's. Ligament sprain (26.8%), muscle strain (17.9%), contusion (13.8%) and concussion (10.8%) were the most common diagnosis. The ankle (23.4%), knee (18.7%), head / face (13.7%), and thigh / upper leg (13.1%) were the most affected body locations. Female footballers sustained more knee ligament sprains during matches. Male players suffered more contusions. Injuries resulted from player-to-player contact (42.8%), non-contact (23.1%) and contact with the playing surface (17.7%). [65]

2.3. Risk Factors

Athletic injuries result from the interaction of multiple Risk Factors (RF) and events. They are a combination of many variables, ranging from musculoskeletal and biomechanical differences in the athlete, to environmental (e.g.: field conditions) and sport-specific factors (e.g.: footwear, playing position, skill level). [9, 66] It is important to understand why is an athlete prone to injury in a given moment or situation. [8, 9]

Bahr & Holme [9] reviewed the methodological approach to RF. They can be athlete-related (internal, intrinsic) or environmental (external, extrinsic). They can also be modifiable (e.g.: muscle strength, flexibility, balance, fitness level, joint stability, coordination, psychological and social factors) or non-modifiable (e.g.: age, gender). There are several examples of extrinsic (e.g.: sports context, protective equipment, rules and regulations, playing surface, coaching education, training) and intrinsic RF. [8, 9]

Meeuwisse [67] proposed a model of sports injury where predisposing (internal, that act from within but are usually insufficient to produce injury) and enabling factors (external, that predispose the athlete from outside) facilitate the manifestation of injury on the susceptible athlete when an inciting event (mechanism of injury) causes the injury.

Ultimately, a football team should focus on having a minimal II and severity. Knowing the existent RF for a particular injury allows both coaching staff and medical teams to develop and implement risk control and prevention strategies. [20]

Evidence suggests several RF for youth football that, although sometimes not supported by enough strong evidence, appear to importantly influence II. Generally, we can considerer factors such as player's age, gender, behaviour, skill level, competitive level (sub elite vs. elite); "style of play" variations (by geographic area) and "coaching style". [10] Other extrinsic (e.g.: dangerous play, play on small fields, inclusion of youth players on adult teams) and intrinsic (e.g.: relation of knee injury and female gender) RF for youth football are suggested by other author. [15]

The effects of potential extrinsic RF such as fatigue, match load and season planning (individually and interrelated) remain under investigated. Also, modifiable intrinsic RF need to be studied. These findings would importantly support the creation of adequate preventive strategies, which would result in a decrease in IR and its' overall burden. [41] More studies are needed to properly understand RF's role in injury occurrence. [3]

The main RF that are present in the literature for football injuries are described below.

2.3.1. Intrinsic

2.3.1.1. Age

Age might affect IR in some cases. But in some cases, no association between age and injury risk in general has been found. [39, 47] Generally, as age increases, so does II. This has been explained with the higher competitiveness, training loads and time of exposure. [5] A peak of II has been described to occur at ages 17-18 years [21], 16-19 years [18] (48.5%, when compared with other players), or 29-30 years [68]. This lack of consensus shows the need for further investigation.

Age has been found to be an important factor, with children sustaining more upper extremity injuries (traumatic and bony – fractures), and adolescents more head, chest, hip / pelvis, and spine injuries. [59] Younger footballers (17-25 years) are at higher risk of injury during preseason. Specific education, advice and awareness of preventive modalities should be emphasised. [20] While some refer that older players are at a higher risk of injury [49], others state that age (<23.9 years) could be a RF for potential ankle sprains [69] in non-contact situations.

Regarding Muscle injuries, they tend to increase with age. [53, 64] Older players (>30 years) show a higher incidence in training than young players (<22 years) (1.19 vs. 1.63 Injuries/1000EH). In matches, young players are also the ones with the lowest incidence of Muscle injuries. The injury types that revealed age-related differences where groin strains (lower in young footballers and highest in intermediate players; 1.61 and 2.71 Injuries/1000EH, respectively) and calf strains (from 0.32 Injuries/1000EH for the young to 1.89 Injuries/1000EH for older players). [53] This difference might be explained by age-related factors (such as increased body weight, flexibility loss, among others) seen in older athletes, although no association between body mass and stature and IR was seen by Hagglund et al. [41, 70] Hamstring injuries are also age-related. Some state that young players (17-22 years) showed lower risk of injury to the hamstrings than older players. [34] This could be related with the level of play of the player. [71] Chomiak et al found that age tend to influence the severity of knee injuries. Younger players sustain more joint sprains, contusion and spinal injuries. Older footballers have more muscle strains, ligament ruptures and meniscal tears. Young footballers (16-18 years) were the ones with the higher IR (joint sprains being the most common). Contusions were more prevalent in 14-16 year old players. [52]

2.3.1.2. Gender

Female players seem to be more affected by some injuries than male. [8] A narrowing of IR between girls and boys is seen over time, probably due to an increase in female footballers' skills. [15] But although gender-related injury pattern differences might exist, investigation is lacking that shows significant differences and allows us to properly address them. Nevertheless, differences have been found for minor injuries [3], and for ACL injuries, as female players tend to sustain three to four times higher rate of these injuries. Several reasons are suggested to explain this: joint laxity, differing anatomical alignment and playing mechanics during play, core stability, hormonal influence, femoral notch size, hamstring weakness, smaller ACL ligament and less strength and conditioning. [15, 60, 72] Male footballers show higher rates of syndesmotic and medial ankle sprains. [55]

2.3.1.3. Body composition / maturity

Player's maturity may affect the level of performance that he can achieve in football. It has been seen that elite football tends to exclude late maturing players, favouring early ones. They must have a reasonably high level on several areas, such as muscle strength, aerobic capacity, speed and coordination. [15] Backous et al found that skeletally mature but muscularly weak boy may be more prone to injury. [73]

Body composition factors (e.g.: weight, height / stature) have been documented in the literature as RF for injury, but evidence remains controversial.

It is suggested that high stature leads to decreased coordination, thus increasing risk of injury. Elevated player stature may predispose young footballers to thigh injuries [74], but height seems to have no effect on ankle injury risk. [69]

Body Mass Index (BMI) seems to be associated with II in some situations. Players who sustained syndesmotic and medial ankle sprains showed higher BMI than uninjured athletes. This is in accordance with the association between BMI and ankle sprains in general. [55]

BMI, height, player exposure, and weight are not important RF for hamstring injury. [71] It was shown that increased BMI (>23.1) and body weight (>72.6 kg) are important are RF for non-contact ankle sprains in football, thus making the athlete more prone to injury. [69]

2.3.1.4. Muscle Function

It seems consensual that muscle characteristics (e.g.: strength deficits) may predispose the athlete to higher II.

Reasons for the occurrence of strains in young footballers can include incomplete muscle development, limited shock absorption and association with the forces needed for kicking / acceleration. [5] Reduced muscle strength may play a role in non-contact injuries of the knee for young and low-skilled players. [52] Players with strength imbalances (e.g.: low hamstring / quadriceps muscle strength ratio) are 4-5 times more prone to hamstring injuries. As a modifiable factor, restoring agonist / antagonist balance significantly reduces IR. [75] The risk of a new groin injury is four times higher in players with weak adductor muscles. [76] It was shown that asymmetries in the eccentric muscle strength of the ankle joint are important RF for non-contact ankle sprains in football, thus making the athlete more prone to injury. [69] Players who sustained ankle injuries show intrinsic deficits in strength (higher concentric plantar flexion strength at faster speeds; lower eccentric eversion strength at slower speeds), low postural stability, higher postural sway that can lead them to ankle recurrence. [77]

2.3.1.5. Flexibility, Hypermobility and Joint Instability

Flexibility seems to be a RF for injury, but no consensus exists. It needs further investigation, but it is suggested that stretching after an appropriate warm-up prior to exercise may prevent Muscle injures. [8] It is suggested that hamstring muscle length and flexibility plays a role in IR, by increasing risk of injury. This remains controversial and needs to be further investigated. [71] Flexibility doesn’t seem to have an effect on ankle injury risk. [69] Reduced Range of Motion (ROM) is a significant RF for groin strains. [49]

Hypermobility is characterized by joint ROM beyond normal limits taking into account the person’s age, sex, and ethnicity. Up to one third of elite football players are hypermobile, but no differences in age, height, playing position and ethnicity are found between hypermobile and nonhypermobile athletes. Players with generalized joint hypermobility show higher II in general and severe injuries and recurrences in particular, which results in more missed days from matches and training. Screening on players’ hypermobility is recommended in order to decrease IR. [78]

Physical assessment findings such as joint instability and abnormality of the spine seem to be related with injury severity. [52] Passive anteroposterior tibiofemoral laxity and passive knee hyperextension may contribute to increased ACL injury risk. Female athletes might benefit from neuromuscular knee stability protocols. [72] This might be questionable as some refer that proprioception doesn't seem to have an effect on ankle injury risk. [69]

2.3.1.6. Previous injury

Recurrences are a reality in Association football. Previous injury is one of the most important RF for football injury. Risk of overall injury is 1.7-3.0 greater in footballers with history of injury. Players that got injured in the previous season were more prone to injury in the next season. The more injuries players sustained, the higher (up to three times higher) the likelihood of a new injury (recurrence or not). [8, 39, 49, 52, 62, 69, 76, 79]

A difference has been found between professional clubs and football academies in terms of rate of recurrence. Price et al reported that only 3% of recurrences were recorded (mostly strains and sprains). This is thought to be due to the decreased pressure to return to competition from academy coaches, revealing greater education and player compliance. Strains and sprains were the most prevalent recurrences, probably because of inadequate rehabilitation or early return to play. Recurrent strains affected mainly the quadriceps (35%), hamstrings (33%) and hip adductors (20%); sprains involved the ATFL (78%) and the MCL (20%). [5] More than 50% of ankle sprains are recurrences. [63]

Previous identical injury was also identified as an important intrinsic RF for lower extremity Muscle injuries. Previous adductor injury is a RF for a new adductor muscle injury. History of injury to other lower extremity muscle groups increased by 68-91% the rate of quadriceps and calf injury. Hamstring injuries are more probable if a previous injury occurred in the hamstrings, quadriceps or calf. This shows that previous injuries in different muscle groups in the lower extremity also increase IR. [41] History of previous injury is one of the main RF for new injuries to the ankle, groin and hamstrings. [62, 69, 71, 76, 79] For ankle injuries the risk is higher during the first six months after injury. [62] The risk of a new groin or hamstring injury is more than two times higher in players with previous identical injury. [76, 79] Young elite football athletes with previous injury are more prone to thigh strains. [74] Cloke et al found 16-year-old players, midfielders, and hamstring injuries more likely to sustain a recurrence. [64] Also, major injuries are usually preceded by minor injuries of the same type and location. [45]

Biomechanical alterations in the lower extremity, remaining deficits in physical conditioning and proprioception, movement pattern alterations due to previous injuries were already suggested as the predisposing factors for this. Psychological factors should also be considered. It is highlighted the importance of proper evaluation by clinicians in order to prevent biomechanical (and other) compensations before returning to play, and controlled rehabilitation programs with specific goals before enabling the player to return. [18, 19, 27, 34, 39, 41, 71, 80, 81] Inadequate rehabilitation and early return to play after injury are often described as important reasons for a potential recurrence. [5, 19, 21, 27, 39, 49, 51, 52] Preseason evaluation might reduce IR by allowing the application of adequate preventive measures (directed for the RF associated with the first injury, the modifications that resulted from the injury – tightness, weakness, scar tissue presence, biomechanical alterations, and neuromuscular inhibition –, or from inadequate treatment). [41, 82] Risk of early recurrence during rehabilitation (when the player is trying to regain fitness) of injuries is also present during the two full months of the playing season (July and August). Risk of recurrence was still strong one year after the index injury. Again, this might be explained by the deficits that settle after the index injury (e.g.: reduced strength, ROM alterations, and structural damage such as scar tissue presence). [27] But preventing the index injury is of major importance, given the impact it has for players and sports. [56]

In order to prevent recurrences during the season, index injuries should be properly and completely rehabilitated, especially slight / minor ones. [20] To keep reducing the rate of recurrence appropriate medical support, personalized rehabilitation, prevention strategies, radiological examinations (in top clubs) and functional testing should be implemented and emphasized. [53, 83]

Low recurrence rates could be due to the existing medical support, personalized rehabilitation and use of more specific and modern functional tests that better prepare the athlete for playing. [35] When medical staff is present, injury situations tend to be dealt with properly. Chomiak et al verified that more severe injuries received appropriate treatment. Less severe injuries were often underestimated or inadequately treated. Only 47% of injuries were treated by physiotherapists, leading to an inadequate rehabilitation. Lack of team physician during matches was suggested as a possible cause for this. [52]

Knowing when to stop is also important. The risk of both increasing and / or prolonging injury is present in up to 40% of footballers that refer to continue playing after a severe injury. [52]

2.3.1.7. Leg dominance

Leg dominance (preferred kicking leg) was found to be a RF for quadriceps and adductor muscle injury. The great exposure to high-risk actions (shooting, passing and crossing actions) is pointed as one of the main causes, associated with the muscle imbalances postulated by other authors. [41, 84] It was also suggested that the player's dominant side is more commonly involved when tackling and being tackled, increasing risk of injury. [19] Price et al found that 54% of all young footballers' injuries affected the dominant side. [5]

2.3.1.8. Ethnicity

Ethnic origin seems to play a role in hamstring strains' rate, as black ethnic originated players show higher IR. [34]

2.3.1.9. Religion

It was found that players fasting during Ramadan sustain more non-contact and overuse injuries than non-fasting footballers. This is thought to be due to the change in nutritional habits with maintenance of training characteristics. [85]

2.3.1.10. Psychosocial factors

Excessive pressure to perform well in sports, poor psychological coping skills and lack of social support has been associated with injury. [86]

Psychological factors such as major life events (e.g.: death of a close friend or family, separation from boyfriend / girlfriend) could increase risk of injury by up to 70%. This shows the importance of investigating in this area. [8, 87]

Some players might be injury prone in general to Muscle injuries due to genetic, physiological, psychological or psychosocial factors (risk-taking behaviours, life event stress and trait anxiety). [41, 88]

2.3.2. Extrinsic

2.3.2.1. Training and matches

Differences in IR between matches and training sessions have been advocated in the literature. Some authors found no difference in injury incidence between matches and training [39, 74], while others report that athletes show 4-6 times higher injury rates in matches than in training. [1, 21, 63]

Generally, injury incidence is higher in youth football matches when compared with training. In matches, adult players get more injuries than young players, probably due to higher match intensity of play and aggressiveness. [10, 15] It is suggested that the amount and quality of training (and also the subjective exercise overload during training and matches) may affect IR (mainly severe). [52] For example, it is suggested an association between Achilles tendinopathy and preseason training sessions' characteristics (e.g.: higher intensity and conditioning for players, such as running activities, imbalance between training load and adaptation from the footballer). [20] This gives coaches and players the role to minimize contact during training sessions and learn about injury prevention strategies that should be implemented for injuries related with training characteristics. [33] This increase in IR is thought to be due to inadequate training characteristics, increased competition among players (for team selection) and use of better recording systems that allow proper consideration of minor injuries by the team physician. [50]

Generally, time of injury during matches is usually studied in 15-minute segments. The second and last two segments were the ones with the highest II. [45] Match injuries tend to increase gradually during the match, peaking in the last mid third of each half and the last 15 minutes. More injuries occur in the second half when compared with the first. [5, 15, 19, 34] Contact-related injuries (73.3% of total) peaks in the last 15 minutes and extra time possibly because of increased player aggressiveness. [45] For top-level female footballers, II was found to be similar between halves but lower in the first 15 minutes of each half. [58] UEFA European Championships recorded more injuries during matches, especially in the second half. Contact injuries were more prevalent in the second half of the match. It was suggested that lack of focus, fatigue, and increased playing intensity (more contact situations by the teams willing to win) can play a role. [47]

In youth academy football injuries tend to occur in the mid third of both halves, and the last 15 minutes. More injuries occur in the second half compared with the first (50% vs. 41%) but a fall after half time is less noted. [5] Muscle II tends to occur towards the end of each half. Particularly, during matches, thigh strains incidence was significantly lower in the first quarter of each half (but a trend for quadriceps strains in the first half was found). Hip / groin strains were less frequent in the first part of each half. Calf strains tended to occur in the last 15 minutes of the match. [53] Cloke et al. found increased risk of thigh muscle injury after the first part of the first half of the match. [64]

Generally, the most common diagnosis were contusions of the thigh and lower leg and thigh strains for matches, and ankle sprains and thigh strains in training. Injury episodes increased progressively during the course of the match. [42]

Muscle strains result from the sum of intrinsic and extrinsic factors, but they don't seem correlated with exposure to matches and training. [74] Although the exposure to train is higher than exposure to matches, no clear differences were found between different turfs and sessions (train, match) when considering muscle strain injuries and ankle injuries for male football players. More investigation is needed to clarify this factor. [2, 3] Ekstrand et al reports that muscle II is six times higher in matches than in training. [53]

Fatigue, both central brain and local muscle, is suggested to play a role in this injury behaviour. Inadequate recovery opportunity during the halftime break is also suggested. A decrease in the eccentric hamstring strength over time was found and could support this theory. [5, 19, 34, 41, 45, 64, 89] General fatigue due to stress, inadequate nutrition, poor sleeping patterns is also suggested as a cause for central nervous system fatigue. [34] Immaturity of both physiological and musculoskeletal systems and neuromuscular fatigue were also pointed as possible reasons. [5] Greig et al found alterations in functional stability after a simulated match (induced fatigue). Changes in balance strategies (more knee and hip balance strategies) were found in the last 15 minutes of the simulated match. This could mean an increased risk of injury and the need for specific proprioception training. [90]

Some authors found that a congested calendar had no influence on risk of injury for elite professional footballers but it is understandable that too many matches in a short period of time can result in fatigue, low performance and increased risk of injury. [13, 91] Dupont et al analysed the effect of 1 vs. 2 matches per week on physical performance and IR in elite professional footballers. It was found that recovery time between matches (72-96 hours) was enough to maintain physical performance levels, but not to maintain low IR (1 vs. 2 matches per week; 25.6 vs. 4.1 Injuries/1000EH, respectively). Inadequate recovery between matches that leads to fatigue and increased risk of injury (mainly overuse injuries) are a possible explanation. [4] UEFA European Championships are played shortly after domestic seasons, Champions League and UEFA Cup. This busy match calendar is suggested to cause physical and mental fatigue to the players, not allowing important footballers to rest and recover properly prior to the championship. The authors emphasize the importance of these effects on young players' injuries. [47] Highest hip / groin II are recorded in March, October and November, correlating with match exposure. In order to prevent injuries a squad / player rotation policy, decreased training intensity in some periods, careful match scheduling, and improved recovery strategies during congested match fixtures is suggested. [4, 44]

2.3.2.2. Match result, match venue and type of competition

It was found that match characteristics were associated with injury occurrence in professional European male football. Bengtsson et al [92] investigated the association between IR and some extrinsic factors such as match result (win, draw or loss), match venue (home or away match) and type of competition (league, UEFA Champions League, UEFA Europa League). Only TLI were considered in a team basis. [92]

Playing away revealed lower IR. In home matches, higher proportion of muscle / tendon injuries and lower proportion of joint / ligament injuries was found though. [92] Hamstring and adductor muscle injuries tend to occur mainly in matches played at home or away (according to different authors). Authors speculated that a different match activity and playing strategy / style in different venues could impact the incidence and nature of injuries, explaining these results. [41, 92, 93] It has been found that, in the second half, losing teams show more high-intensity runs, probably because they have to press the opponent in order to win the ball. [4]

More severe injuries (>1 week of absence) were recorded in more important competitions (UEFA Champions League), possibly because of the increased intensity of the game and use of not fully rehabilitated players, leading to recurrences. [92] More calf muscle injuries and less quadriceps muscle injuries were recorded in UEFA Champions League when compared with other types of matches. The discrepancies could be explained by different types of play according to the type of competition. [41] Differences in ball possession, time situated in the attacking zone, playing intensity, number of sprints / passes and levels of anxiety have been identified in the literature. [41, 94] More severe injuries are recorded in the opponents' half of the pitch. [52]

Injuries influenced match results, and an association between injuries and team performance was suggested (more injuries occurred in matches resulting in a loss or draw – match result influences the team's strategy, leading to more dangerous play; a match was more likely to finish in a loss or draw if 2 or more injuries – higher match II – were sustained during the match). Not only the game plan could be affected by forced substitutions, but also the injured player's ability to perform could be diminished (even if he doesn't need to come out of the pitch). This emphasizes the importance of preventive measures in football teams. [92, 95, 96] These findings are not present in national teams' players, suggesting that by having players with homogenous skills, injured ones can be replaced by team mates with equal skills. [47] IR in youth national teams are lower than in adult national teams. Younger and less experienced players could also be used more frequently in less important competitions. [5] Azubuike et al found an association between injury severity and the number of substitutions because of injuries, suggesting that a substitution after an injury can be an indicator of its severity. [18]

2.3.2.3. Season Schedule

When considering the part of the season, preseason shows different IR when compared with the competitive season. [19, 20, 41] Injuries were three times more prevalent in preseason training than regular season. In-season match IR was higher than in the postseason. [63] The period after summer break (preseason, usually September) and winter break (January) shows injury peaks, suggesting loss of conditioning. [64] A significant decrease in II was seen in the periods after breaks in activity (July and December), and a peak rate was reported both after preseason training and a mid-season break. [5]

Several authors suggest that, at preseason, players have not yet reached appropriate fitness levels that allow them to properly withstand the particularities of competitive football. It is also suggested that inappropriate training program (e.g.: increased intensity) or a too intense one to allow adaptation (fatigue related) are probable predisposing factors. [5, 13, 19, 20, 63] It has been shown that elite footballers, after the closed season, show bone remodelling imbalance that could result in bone strength reduction and thus higher risk of injury (e.g.: stress injuries). [97] Woods et al suggest the possibility of association between IR in preseason and higher training loads. [20]

The implementation of appropriate preseason training (e.g.: individualised fitness programmes) and fitness programs (even during the closed season) may decrease IR. [19, 20]

Overuse injuries (such as tendinopathies) are more prevalent in the preseason period. [19] Most severe injuries peaked on preseason and after midseason break. [10] An increase by 40% in IR of the quadriceps muscle is seen during preseason. The increased number of kicking actions during this time likely explains this finding, and eccentric exercise protocols should be implemented to prevent it. [41] Thigh muscle injuries, common in youth football, are related with non-contact mechanisms of injury in more than 80% of cases. Muscle conditioning protocols during preseason should be emphasized in order to alter this tendency. [64] To prevent an ankle sprain peak in August / September, implementation of proprioceptive and conditioning training (including preinjury measures of ankle stability) during the closed season and preseason should be implemented. [33]

The other three main muscle groups report higher IR in the competitive season. Particularly the hamstrings, whose mechanism of injury is typically high-speed running in matches, are more prone to injury during competitive away matches. Again, fatigue is identified as a factor that could explain IR variations over the season. [41]

An interesting factor raised by Hagglund et al was that sustaining an injury during UEFA championships (during closed season, after regular football seasons) may lead the player to miss vital preseason preparation with his team, further increasing risk on injury / recurrence during the following normal season. [47]

2.3.2.4. Geographic region

Medical and coaching staff should be aware of injury pattern in different geographical regions with differing styles of play, and act accordingly. [15]

Teams from different regions / countries seem to have different match injury incidence and pattern (higher risk for English and Dutch teams). It remains under investigated but possible explaining factors have been suggested, such as playing intensity, differences in seasonal compositions, weather and pitch conditions, or even the characteristics of the medical staff. [13]

2.3.2.5. Type of turf

The type of turf (e.g.: natural grass, artificial turfs) appears to have a role in IP. Twenty-four per cent of football injuries could be attributed to unsatisfactory playing surfaces. [3, 52]

Natural grass (NG) pitches are considered the standard field surface for football practice, but maintenance costs are considerably high throughout the year. Artificial turfs (AT) are seen as cheaper (and FIFA approved) options, as maintenance costs are lower (saved money can be invested in injury surveillance studies, for example), utility options are greater (wide range of sports and activities) and climate characteristics are not a problem when compared with NG pitches. [3, 66, 98, 99]

Different types of AT are seen in football (1st to 4th generation) that try to mimic the playing characteristics of NG. [3, 66] First generation artificial turf (1GAT) (Astroturf TM), presented in the 1960s, was a short length grass fibre carpet on top of minimal padding over concrete. When compared with natural grass, 1GAT show increased stiffness, heat retention and sliding friction. [3, 66, 100] In the late 1980s, the second generation turf (2GAT) was created, with longer and thicker fibres (22-25mm), increased padding, sand filling and a rubber base under the turf to reduce stiffness. [2, 3, 66] In the 1990s, a third generation artificial turf (3GAT) was developed, believed to approach NG turf characteristics more than any of the previous artificial fields by minimizing friction and increasing cushioning. Its' sand and / or rubber infill with longer fibres (50-60mm) was built specifically for football. [3, 66, 101] Fieldturf TM is the most recent artificial turf (fourth generation) (4GAT) and its' infill consists of three layers (bottom, of silica sand; middle, combination of cryogenic rubber and sand; and top, of rubber). [3]

Apart from this, doubt and controversy remains about the following questions: is there an association between turf characteristics and II and pattern? Which type of turf (natural or artificial) is more player friendly in terms of injury occurrence? [3, 66]

Lacerations, ankle injuries and ligament and cartilage injuries are more likely in AT when compared with NG turfs. In the contrary, Muscle injuries appear to decrease in AT. Rapid changes between surfaces also appear to increase risk of injury, but this needs to be further investigated. Other inter-relating RF (e.g.: shoe-surface interface; foot loading; impact attenuation) should be considered in order to decrease risk of injury. [3, 102, 103] However, the results remain contradictory, revealing no differences on IR between turfs. [2, 66, 93]

Hershman et al [104] compared the rate of knee and ankle sprain injuries sustained on NG and 3GAT (FieldTurf TM) surfaces while playing in National Football Leagues (NFL) 2000-2009 seasons' matches. As training injuries were not considered, it was found that the IR of ACL sprains and eversion ankle sprains was significantly higher in AT than on NG surface (67% and 31%, respectively). No significant difference was found for MCL sprains and inversion ankle sprains. These results were thought to be due to other contributing factors (e.g.: mechanics of injuries; interaction between surface and footwear), although not specified by the authors. An injury was reportable if the player was removed from the session / match (or missed 1 day after the injury) or if it was a fracture, concussion, dental injury or heat-related problem (regardless of time-loss). [104]

Williams et al [3] found a likely increased risk of ankle injury when playing on AT. Playing in 1GAT seems to result in more abrasions and lower extremity sprains when compared with NG. [66] Burns and frictions are less prevalent when playing in modern high-quality artificial turf pitches. [93] Less lower extremity injuries are also recorded in NG when compared with 2GAT. No difference in IR was found between 3GAT and NG, although injury pattern differs. [66] Preventive measures for teams that regularly train and play in AT was suggested. Inconsistent findings regarding knee injuries were found. [3] Several authors found no differences in IR, pattern, severity, nature or cause between AT and NG. [2, 102, 103, 105] Others refer that, although injury risk is similar, a tendency for more ankle sprains and less quadriceps strains on AT, and more calf strains on NG exists. [93]

Teams playing in 3GAT reported less muscle injuries (6.16 Injuries/1000MH) in matches than those on NG (8.75 to 9.58 Injuries/1000MH). [53] Muscle strains seem to occur more often in NG pitches, having AT a protective effect (of more than 90%). [3]

For injury severity, namely slight injuries (1-3 days of absence), no harmful effect of playing in AT was found. The effect of turf type on minor (4-7 days) and moderate injuries (8-28 days) needs to be clarified by further investigation due to inconsistent findings. Severe injuries (>28 days) also lack a clear pattern of effect, but they seem to occur less times when playing on AT and young female footballers seem to sustain more severe injuries in AT. [3, 52]

Foot loading patterns in different types of turf seem to explain different injury patterns. Ankle injuries might occur because of a higher degree of inversion in AT due to higher relative loads on the central forefoot and lesser toe regions. NG shows higher relative loads on the medial forefoot and lateral midfoot, which might be related with knee ligament injuries. [3, 106]

Injury might occur as a result of overloading the tissues. Turf's impact attenuation properties are important to prevent this. Although NG shows the best results, they depend on the turf's usage, so the authors recommend the use of a 3GAT in this matter, both in dry and wet conditions. Also, playing on AT seems to cause more fatigue in players, possibly increasing risk of injury. Higher rates of low back pain are recorded among young footballers that train in artificial pitches. [3, 101, 107]

In order to prevent lower extremity injuries and reduce risk of injury, it is important to appropriately monitor field conditions (e.g.: holes, uneven playing surface and other irregularities) as treatment on the playing ground is inexistent in more than 50% of cases. [1, 52] As dry playing surface seems to be associated with preseason's IR, it is suggest the use of irrigation systems and pitch watering and softening. [20, 108] Adequate maintenance of pitches helps preventing ankle injuries. [33] Playing in the winter months is also suggested as an injury prevention strategy. [108]

2.3.2.6. Weather

The physical and environmental characteristics of the playing surface (both natural and artificial) may be as important for IR as the type of turf itself. Surface dryness, environmental temperature and surface hardness seem to play a role on this. [66] Playing in wet AT seems to decrease II. [3, 109] Players might also modify their movements in wet surfaces. [110]

Studies relating II and weather conditions are scarce. The influence between weather and surface (related with shoe-surface interface) can be associated with injury occurrence as concluded by Azubuike et al [18]. They found a significant association between injury type and weather conditions (78.9% of injuries occurred in hot or sunny conditions while 20.1% happened in rainy or cold weather) but not between field conditions and weather (although 81.4% of injuries were reported in either hard or dry fields). [18] Ground surface is influenced by weather conditions (softening of the pitch when it rains, for example). It is too soon to be certain of the influence of weather on injury occurrence because it is understudied, as it remains difficult to objectively measure weather conditions during football practice and no highly interobserver reliable evaluation method for surface conditions is available yet. [18, 45]

Effect of climate region (warmer vs. colder) had been studied in what concerns IR. Not a lot has been studied yet, and controversy exists, as warmer regions have shown higher and lower IR. A pattern like this was not found for Muscle injuries in the lower extremity. [41, 109, 111, 112] Racinais et al showed that training in a hot, dry environment impairs match-running performance. A week of training on this environment causes heat acclimatization in football players, but these are highly individual. [113] Woods et al suggest an association between pitch dryness and Achilles tendinopathy occurrence in 70% of cases. [20]

One study found that almost half of all severe injuries (both traumatic and overuse) occurred in autumn. The author suggested an association between weather conditions and pitch quality. [52]

2.3.2.7. Playing position

A specific relationship between injury and player position has been referred. [15] Generally, the greater the activity and covered distance during matches, the higher the risk of a musculoskeletal injury (due to increased acceleration / deceleration activity). [9, 49] Different positional roles implicate different playing characteristics. Generally, defenders tend to "tackle hard", attackers are intended to strike the ball into goal, and wingers are known for their running. [18]

According to the positional role defenders (34.3%) and attackers (31.4%) registered higher II than other players (e.g.: goalkeepers (GK), 9.8%). [18] Defenders (36%) and midfielders (35%) got injured most often than attackers. [5] Higher incidence of lower extremity injuries are sustained by defenders followed by midfielders, attackers and GK. [68] Midfielders and attackers seem to be at higher risk of thigh muscle injuries. [64, 114]

GK don't follow outfield player's (OP) injury pattern (IR don't increase with age). [5] GK (who perform less running, more ball reaching, and more collisions with goalposts) show a higher rate of upper extremity, trunk and head injuries than the rest. [68] Also, it was found that GK have similar physical and psychological profiles to OP, but that they sustain fewer (up to 25% less) injuries than them, except for head and face injuries during contact play. They also suffer more upper extremity injuries than OP. [15, 45] GK show decreased rates of Muscle injuries for all major groups of lower extremity (quadriceps, hamstrings, adductors and calves). [41] Probably because "running" is not the major component, GK show fewer hamstrings strains than OP. [34] No difference was found regarding FP between GK and OP. [15, 45]

2.3.2.8. Level of performance

Most of the studies use, as subjects, athletes from amateur clubs, high schools, universities, regional clubs, and elite teams. This makes comparison between studies difficult, and studies addressing the level of performance of the athletes are scarce. Several factors are theorized as possibly affecting injury patterns. They are player fitness, pitch quality, quality of officiating, FP, postural / joint integrity, musculoskeletal structure and biomechanics of movement. [3] If the level of the competition / tournament rises, IR also tends to increase. [21] Also, different levels of competition might implicate different injury patterns. Suggested reasons for this are higher intensity of competition, aggressiveness in player-to-player contact, higher match exposure, limited rest period and risk-taking behaviour. [18, 55] It is suggested that high-skilled players train and compete more intensely, achieving a higher level of fitness that may be protective. Low-skilled players lack conditioning and fitness, making them more prone to injury. [15] Chomiak et al documented that players with poor physical condition and / or low-skill sustain more severe injuries. [52] Hamstring injuries were more common in professional football clubs, probably because of the higher physical demands of the game. [34] Azubuike et al suggest that more experienced players acquired skills that make them avoid injury-prone actions (mechanism of injury). But they also found that players with 6-10 years of experience tend to sustain more injuries (58.8%) than others. [18] Poor technical skills (as a predisposing factor for injury) by sub-elite youth players, when compared with elite youth football, might be counteracted by the less time and intensity of play / train, although exposure seems to play a more important role in relation to injury. [10]

Professional club's medical staffs allow more accurate injury diagnosis and adequate rehabilitation before allowing the player to return-to-play. Also, larger squads (as usually seen in professional clubs) allow player rotations and rest. [44]

Injury severity is suggested to increase from lower to higher leagues, probably due to different competitive natures and levels of participation. [18] Walden et al showed that footballers with national team participation have similar risk of injury when compared with players with no such obligations. They point that, apart from the tendency to use uninjured players internationally, these are also fitter, more skilled and more conscious about prevention / recovery modalities. [40]

Kristenson et al followed 26 football clubs for 9 consecutive seasons. Differences on IR was studied between newcomers (undergoing first season with first-team contract after being promoted from a youth academy) and established players. A TLI definition was used and exposure to training / matches was recorded. [68]

Newcomers showed decreased general IR, but a higher fracture rate (especially stress-related bone injuries) when compared with established players. This could be explained by reduced match load / exposure or differences in attitude toward seeking / receiving medical attention, but not because of lack of physical adaptation to training methods as some authors suggest. Differences in match / training load compared with youth academies and just being younger might play a role for stress-related bone injuries. [68]

This difference between younger and older footballers suggests that a difference exists between elite and sub-elite level football. Not only the demands of return to practice are different but there's also a difference in the levels of aggressiveness and respect for rules and fair play. All these factors contribute to a decreased incidence and severity of injury in youth football. [10]

2.3.2.9. Footwear

Inappropriate footwear may lead to too much or too little frictional force, thus leading to lower extremity injury. [115] Adequate running shoes may decrease lower leg IR during preseason. [20] Sever's Disease (or calcaneal apophysitis) is the example of a condition than can evolve from playing in hard fields with cleats with insufficient heel / arch support. [1] It is suggested that footwear might play a role on the effect of forces to the knee, and more specifically to the MCL, usually affected by injuries. [5]

Footwear and shoe-surface interface are referred as an important risk factor for football injuries and, more particularly, for different injury patterns between different playing surfaces. [3] Nevertheless, footballers often refuse to wear any kind of foot / ankle prophylaxis other than tape, because of its effect on football shoes fitting and effect on performance. They even prefer shoe comfort over injury protection when choosing football shoes, perhaps because they don't perceive shoes as a cause of injury. [20, 63, 116]

High peak torques between shoes and playing surfaces have been pointed as a risk factor for lower extremity injuries. Peak torque is higher on AT, especially with grass shoes on 3GAT and turf shoes on 1GAT. This emphasizes that using appropriate footwear can be an important and easy injury prevention strategy to be used by footballers. [3]

Rotational stiffness is the rate at which torque increases with applied rotation and is another shoe-surface mechanical interaction measure that allows us to know the rate of loading upon a joint during cutting manoeuvres. The higher the rotational stiffness, the higher the joint load, and less the time for protective forms of neuromuscular control stabilization. Rotational stiffness is higher on AT, but footwear didn't affect these results. This requires further investigation though. [3, 117]

Studies on the effect of different types of footwear on IR are scarce. One of the reasons for this difficulty when trying to compare grass with 3G surfaces is that within 3GAT systems a variation in injury patterns and biomechanical responses exists. [110]

McGhie and Ettema [110] studied the impact properties of three 3GAT systems (professional level with underlying shock pad; recreational level; professional level without underlying shock pad) when combined with three cleat configurations (turf cleats; traditional round cleats; bladed cleats). For each combination of cleat-turf two running tasks (stop sprints – straight sprint with rapid deceleration; cut sprint – sprint with 90º cut to the left) were recorded using a force plate, solely under dry conditions. [110]

It was found that an underlying shock pad doesn't increase impact absorption (contradicting that greater potential for deformation leads to improved absorption of impact forces) and that turf cleats produce the lowest impact forces. Recreational level 3GAT system displayed inferior impact absorption (increased force of impact in stop sprints and decreased time of contact for both running tasks) than the other turf systems. [110]

Recreational level 3GAT provides less impact absorption than the other systems. Turf cleats, intended for recreational level 3GAT systems, showed the least impact forces. This can potentially affect all the amateur footballers that use this turf system and footwear, although it is on the professional level that the individual exposure is the highest. [110]

Differences between different cleat types regarding time of contact (t_{con}), peak impact (f_{imp}) and approach velocity (v_{app}) are thought to be related with cleat configuration and / or shoe construction (impact-absorption qualities). Time of contact varies between 3G surfaces but doesn't vary between cleat types. On the other hand, the magnitudes of peak impact forces don't indicate 3GAT system as a hazardous playing surface. [110, 118]

In order to prevent injuries, boots with smaller cleat and with a more pliable upper could be implemented when playing. [3, 108, 117]

2.3.2.10. Foul play

Foul play (FP) is an important (and potentially preventable) cause of injury in football. This dangerous play is possibly due to the high competitiveness of football and, in professional clubs, the need to win in order to earn financial benefits and glory. [15, 119] It is consensual that low adherence to fair play policy leads to an increased injury risk. Investigation shows the association between FP and contact-related injuries. [1]

FP-related injuries (20.4% of total) showed no specific pattern, but were caused by the opponent in 98% of cases. [45] Yard et al documented 12.2% of FP injuries among High School footballers. [65] ACL injuries increase with body contact and FP. Ankle injury resulted particularly from FP. [52]

Referees have to implement the laws of the game in order to prevent injuries by helping to reduce aggressiveness between players, trainers and spectators. [119] Referees seem to be right on their decisions in up to 70% of the situations but, in the other hand, in 60% of the FP that leads to an injury no sanction is given by the referee. [119, 120] When severe injuries occur, only two thirds of the offending players were found to be sanctioned by the referee. [52]

It is suggested that the laws of the game should be changed focusing injury prevention to protect players from dangerous play. [119] Proper rule enforcement, discouragement and limitation of violent contact, promotion of sportsmanship and fair play may reduce this risk and lead to more safety and enjoyment in football. [1, 10]

Aoki et al reports that FP-related injuries showed a gradual decrease tendency over the years in Japan. As no match rules changed, it is thought that the educational consequences of the study-related meetings (annual data feedback system) had a role to play. This showed to team physicians, club teams, players, match coordinators, J-League office and referee committee members the importance of safer play and prevention measures intended to reduce risk of injury. [45]

As stated before, most injuries (overuse mainly) are multifactorial, resulting from the dynamic interaction between RF (intrinsic and extrinsic) and events. It is important to analyse this interaction in order to find and act on those RF that are modifiable. This intervention should be done as part of a prevention plan, allowing the player to optimize his performance (by increasing physical fitness and decreasing absence from sessions).

2.4. Injury prevention

Youth football associated injuries cause an economic burden for the health care system. This gives sports medicine professionals a challenge to identify patterns and develop effective treatment and preventive programs. [15]

Understanding the differences between young athletes and mature adult athletes, as well as behavioural and environmental risks, will help clinicians guide the prevention, diagnosis and management of sports injuries in children and adolescents. [60]

In order to prevent the overall incidence of injury, prevention of recurrences (that remain high) should be emphasized. [39] Knowledge about II, type and risk factors allows us to know where to begin and, more importantly, what are the most pertinent prevention programs. [8] If athletic performance is to be enhanced, athletes, medics, physiotherapists, trainers and coaches must be taught to implement prevention measures to their therapies and training programs. [8] Clubs' management influence players' behaviour and should contribute to a positive health culture, which has to insure that everyone is involved and committed in the prevention / recovery programs. [20] Prevention should include active (the athlete cooperates and modifies his behaviour; an example is the FIFA's active prevention program "11+") and passive (doesn't have to perform active adaptations; such as compliance with new rules, use of equipment) strategies. [8, 18] Shin guards are intended to reduce the incidence of soft tissue injuries, although evidence is lacking. [15] Youth Football Academies should focus on injury awareness and preventive strategies, quality of advice, and education for young footballers. [20]

Generally, injury prevention can be summarized as three E's: Education or behavioural interventions; Environmental interventions; and Enforcement or legislative interventions. [60] This prevention should be done by a multidisciplinary team that includes coaching and technical staff, directors, medical departments, referees and even players. Particularly for youth sports injuries, six strategies are pointed as potential mechanisms for injury reduction. [121]

- Preseason physical examination: first opportunity to prevent injuries by detecting conditions that may predispose to injury, life threatening or disabling conditions, musculoskeletal problems that need rehabilitation prior to playing, and meeting of legal and insurance requirements; fitness level and general health (including psychosocial and psychological health) assessment can also be performed along with counselling on health-related issues. [122]

- Medical coverage at sporting events;
- Proper coaching; adequate warm-up and stretching should always be emphasized.
- Adequate hydration;
- Proper officiating;
- Proper equipment and field / surface playing conditions (e.g.: playgrounds, playing fields, surfaces). Legislation development is also included.

Recovery strategies (e.g.: hydration, nutrition) and prevention proprioceptive measures should also be present in the closed seasons. Conditioning exercises for the rectus femoris muscle during the closed season and a gradual increase in training volume is suggested as an adequate strategy to prevent preseason injuries that affect this specific body location. [20]

The transition between closed season and preseason is characterized by an increase in intensity and duration of activity. Explosive and repetitive movements predominate. Prevention programs should be implemented to overcome this lack of conditioning, fitness and skills. [15, 63]

It has been suggested that a preseason isokinetic assessment would be an important way of evaluating specific RF (e.g.: muscle imbalances) and implement adequate prevention / strengthening programs to athletes in high risk of injury. This is easier to do in professional football clubs, as it would be too expensive and time consuming for recreational players. [75]

Injury prevention programmes should be tailor made according to football's injury profile / pattern. [16] It is suggested that working the hamstrings muscle group endurance is important to prevent and rehabilitate hamstring injuries, but that it remains under investigated. [34]

For injury prevention in youth football, adherence to the rules of the game, proper coaching, and adequate refereeing is recommended and should be emphasized. [15, 33] Not wearing protective equipment properly (e.g.: shin guards, taping) might lead to severe injuries. [52] The use of protective equipment and change / enforcement of rules would help prevent collision forces during play that lead to severe injuries (e.g.: fracture). [17, 18]

Other functional test might be done by the medical staff during preseason. Verifying the percentage difference between the squat jump and counter movement jump might be an adequate test to identify high-risk of thigh injuries. Lower difference leads to higher risk. [74] Balance test, player interviews or clinical examination don't increase the ability to identify players at risk. [62]

Methodologically strong investigation should be developed. Care has been taken by UEFA and FIFA to develop the methodology of epidemiological studies of football injuries. [36] This standardized approach to football injuries provides epidemiological data and the opportunity to monitor and prevent injuries. [43] Several injury surveillance systems [123-127] (e.g.: player or medical staff reported injuries; weekly or match report questionnaires), specific for football, have been created, but all of them have pros, cons and definitions that need to be considered according to the objective of the investigator. Even so, data collection procedures and injury definitions are often different between studies thus making them difficult to compare. [36] Prospective studies allow an adequate analysis of injury patterns, but more than one season (study period) recording is recommended. [39] Long-term injury surveillance studies should be implemented to give all the members of the football community a higher awareness of injury circumstances, help identify high-risk groups, allowing them to intervene accordingly while limiting the costs. [21, 45]

The aim of the present study is to describe injury characteristics, prevalence, and incidence and identify associated Risk Factors for musculoskeletal injuries in a youth Football Academy during one single season.

3. METHODOLOGY

3.1. Study design

This is a descriptive epidemiological study with a prospective, cohort design.

This design allowed the description and characterization of injury occurrence patterns in Under-19 (U-19) (juniors) footballers from a Portuguese Football Academy during the 2012 / 2013 season (preseason and competitive season).

This avoided recall bias and enabled associations between injury variables and RF. [12] It also allowed the analysis of injury distribution and frequency, etiological mechanisms and associated RF, location, type, severity, evolution of injuries and to measure the exposure to risk of injury. [39]

3.2. Objectives of the study

3.2.1. General

This study has three main purposes:

- Describe the prevalence and incidence of musculoskeletal injuries in a Football Academy, its' characteristics (severity, type, location, pattern of occurrence) during the preseason (August to mid-November) and competitive season (mid-November to June) of 2012-2013, as recorded and treated by the medical staff of the Academy. Due to independent administrative reasons (academy closed its' facilities in Portugal) it was not possible to follow the team during all season. So, the study period was eight months, divided in preseason (August to mid-November) and competitive season (mid-November to March);
- Identify injury associated Risk Factors (age, height, weight, BMI, dominant leg, playing position, risk exposure time, circumstances, severity of injury, previous injury, season period) and mechanisms;
- Compare Medical Attention Injury and Time-loss Injury definitions according to musculoskeletal Injury Prevalence, Incidence and characteristics.

3.2.2. Specific

This study has several specific purposes:

- Determine exposure time to training sessions and matches;
- Determine the mean absence time, due to injury, for training sessions and matches;
- Determine Injury Incidence throughout the season, and it's variation during the preseason and competitive season, and training sessions and matches;
- Quantify the amount, incidence, frequency distribution pattern for location, type, side, circumstances, severity, monthly distribution of injuries (recurrence; type of session; type of surface; contact / non-contact; foul play);
- Quantify the amount, incidence, frequency distribution pattern for location, type, side, circumstances, severity, monthly distribution of Haematomas / Contusions, Muscle injuries, Joint injuries, Moderate and Severe injuries (recurrence; type of session; type of surface; contact / non-contact; foul play).

3.3. Variables in Study – Operational Definition

The definitions used in this study are in accordance with the consensus statement on injury definitions and data collection procedures developed for football injuries [12] (Attachment 1) and other recent injury studies [13, 42-44]. UEFA and FIFA's F-MARC are developing a uniform definition of football related concepts. This allows the correct and uniform collection of data by the investigation teams and, consequently, comparison between studies. Concept definition and data collection methodology have been described as the main reasons for the inability to compare studies. [12, 36]

The concepts that need to be defined are: Injury; Recurrent Injury; Injury Severity; Injury Classification (Location, Mechanism of injury, Type, Body side, and others); Injury Incidence (II); Exposure time; Match exposure; Training exposure; and Foul play (FP). These concepts are defined below.

An **Injury** is defined as any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time-loss from football activities. [12] This definition allows the referral of two types of injuries:

- **Medical Attention Injury (MAI):** when the player receives medical attention by a qualified physician;
- **Time-loss Injury (TLI)**: when the player is unable to take a full part in future football training or match. The term "future" also includes the day of injury.

Every injury should be recorded according to the need of medical attention and / or time lost.

Multiple injuries sustained in a single event should be recorded as an injury with multiple diagnosis and injuries not related with football training or match should not be recorded. Physical complaints should be recorded separately from illnesses and disease episodes. [12]

When using a MAI definition, injuries that cause both absence (TLI) and no absence from play are considered. If a TLI definition is used, slight injuries (that cause no absence) are excluded.

A **Recurrent Injury** is an injury of the same type and location of a previous injury which occurs after a player's return to full participation from the previous injury. [12] An athlete is considered fully rehabilitated when the medical staff allows his full participation in a training session or match. It was also suggested that an athlete should be able to participate in a match or comply fully with the coach's instructions in the field in order to be considered rehabilitated. [13, 36] A contusion, laceration or concussion is not considered a recurrent injury. [12]

This definition considers three types of recurrent injuries [12]:

- **Early recurrence**: occurring 0 to 2 months after player's return to full participation;
- **Late recurrence**: occurring 2 to 12 months after player's return to full participation;
- **Delayed recurrence**: occurring more than 12 months after player's return to full participation.

Injury Severity is defined as the number of consecutive days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection. [12] The day of injury is considered day zero and doesn't count for severity determination. If in the next day the player fully participates in the training session or match, a severity of zero days is recorded. If the player leaves the study or the study ends before total recovery from injury, estimation should be done regarding how many days are left until full training or match participation. An injury should be recorded as a "career-ending injury" when a player retires from play due to it. [12] Injury severity can be categorized according to the days of absence from training and matches in:

- **Slight**: 0 days of absence (able to train / play the day after the injury);
- **Minimal**: 1 to 3 days of absence;
- **Mild**: 4 to 7 days of absence;
- **Moderate**: 8 to 28 days of absence;
- **Severe**: more than 28 days of absence.
- **Career-ending**.

Injury classification involves the recording of information on [12]:

- **Location:** divided in main groups (e.g.: upper limbs) and category (e.g.: upper arm; elbow; forearm). The Orchard Sports Injury Classification System (OSICS) is also used to classify the injuries;
- **Mechanism of injury**: defined as "the fundamental physical process responsible for a given action, reaction or result" (i.e. the mechanism of injury is the physical action or cause of injury). When combined with RF (predisposing factors) the athlete will be more prone to injury. [3] Price et al found that, for young footballers, the most important mechanism of injury is running. [5] An injury can result from trauma (acute injuries) or overuse. Trauma is the main mechanism of injury in football and can be due to contact (e.g.: tackle or being tackled, head the ball, player-to-player, player-to-ground / ball / goalpost) or non-contact (e.g.: run, twist / turn, shoot, land). [1, 19] Overuse injury is defined as a pain syndrome of the musculoskeletal system with insidious onset and without any known trauma or disease that might have given previous symptoms. [36] So, injuries can be recorded as "traumatic" – resulting from a specific, identifiable event – or "overuse" – caused by repeated micro trauma without a single, identifiable event responsible for the injury. A traumatic injury can be classified as a sprain (acute distraction injury of ligaments or joint capsules), strain (acute distraction of muscles and tendons), contusion (tissue bruise without concomitant injuries classified elsewhere), fracture (traumatic break of bone), dislocation (partial or complete displacement of the bony parts of a joint), or other (injuries not classified elsewhere. Examples: wound, concussion, etc). [36]
- **Type:** divided in main groups (e.g.: muscle and tendon) and category (e.g.: muscle rupture / tear / strain / cramps). The OSICS is also used to classify the injuries (Muscle

Injury: Muscle rupture / strain / tear / cramps: ; Joint injury: Sprain / ligament injury; Tendon injuries: Tendon injury / rupture / tendinosis / bursitis);

- **Body side** (left, right, bilateral, not applicable);
- **Other classification issues:** Occurred during match or training? Result of contact with player or object? Result of a violation of football laws? FP classified according to referee's decision (own / opponent) and sanction. [13]

Injury Incidence (II) is calculated dividing the number of match and training injuries by the total number of hours of exposure, times 1000 h. It is expressed as the "Number of injuries per 1000 Exposure Hours" (No. Injuries/1000EH). [7] This data should be differentiated for training and match exposures. [12]

Injury Prevalence (IP) is the proportion of athletes who are injured at a given time.

Exposure time is the number of hours of exposure for each player. [36]

Match exposure is defined as play between teams from different clubs. [12]

A **match** is defined as any scheduled friendly or competitive match with the club. [13]

Training exposure is defined as a team based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' football skills or physical condition. Theoretical sessions are not included. [12]

3.4. Population / Sample

The study population was young footballers (16 to 18 years) signed and playing in the first team of a Football Academy. Sample was non-probabilistic (type) and convenient (sample strategy). All thirty players from the Football Academy consent to participate in the study and were considered for inclusion. In order to obtain a homogeneous and representative sample, some inclusion and exclusion criteria were applied to the players. As a result, nineteen players were part of the study sample.

3.4.1. Inclusion criteria

- First team contract within the Football Academy. Nine players that played in the Academy during trials were excluded from the study, as they had no Academy contract and also not enough duration of participation in the study period.
  - When a player was transferred (or left) from the team all his information was recorded until that moment. If he was injured, an estimate was done about the time to full recovery. [12]
  - When a new player was transferred to the team, information about him started to be recorded. [12]

3.4.2. Exclusion criteria

- No written informed consent from player.
- Absence (from training and matches) longer than 20% of Total Exposure Time. Absences caused by injuries acquired during the study period were not included. Two players signed in the Academy failed to participate in more than 80% of the study period and were, therefore, excluded.

3.5. Instruments and data collection

The data collection instruments for this study were used by the physiotherapist in order to record information about the players, the injuries they sustained, and regarding training sessions and matches during all the preseason and competitive season.

Three different forms were necessary for the data collection (Table 1). FIFA F-MARC's forms were used in this study to record information. [12] The explanation of variables is separated in three tables, according with the form they are in.

Table 1 – Data collection forms

FORM	WHAT?	WHO?	WHEN?
Players' Baseline Information Form	Player's characteristics	Player	When a player enters the study
Match and Training Exposure Form	Player's match and training exposure time	Coaches	Every match / training session
Injury Report Form	Classification and circumstances of injury	Medical staff	When an injury occurs

- **Player's Baseline Information Form:** Also used as a written informed consent, this form (Attachment 2) gathered anthropometric and previous medical history data in the beginning of the study period. This included players' age, stature, body mass, playing position, dominant leg and information on previous injuries and / or surgeries. [12, 36] The variables described in Table 2 were used to identify and generally characterize each footballer.

Table 2 – Variables in study (player's baseline information)

NAME	DESCRIPTION	TYPE	VARIABLE DOMAIN
ID*	Athlete's Identification	Quantitative Discrete	Record with no decimals (Ex.: 1)
Age	Age (years) (y)	Quantitative Discrete	Record with no decimals (Ex.: 16 years)
Stature	Stature (cm)	Quantitative Discrete	Record with no decimals (Ex.: 160 cm)
Body_Mass	Body Mass (kg)	Quantitative Discrete	Record with no decimals (Ex.: 80 kg)
BMI	Body Mass Index (kg/m^2)	Quantitative Discrete	Record with one decimal (Ex.: 20 kg/m^2)
Gender	Gender (M/F)	Quantitative Discrete	0 = Male 1 = Female
Domin_leg	Dominant leg (L/R/B)	Qualitative	0 = Bilateral 1 = Right 2 = Left
Play_pos	Playing Position	Qualitative	1 = Goalkeeper 2 = Defender 3 = Midfielder 4 = Attacker

*Just for data analysis purposes

- **Match and Training Exposure Form:** Form (Attachment 3) used to record players' attendance and individual exposure (in minutes) to training sessions and matches. This form also collected information about the sessions, such as type (e.g.: training, match), date and part of the day (e.g.: morning, afternoon) and playing surface (e.g.: natural or artificial turf). [36] The variables related with the training session and matches, informing also about the individual exposure times for each player are explained in Table 3.
- **Injury Report Form:** A short and simple report form was used to record information regarding injuries (Attachment 4). When an injury occurred, data regarding identification of the player, date, type of injury (e.g.: fracture, sprain), location (e.g.: knee, ankle), injured side, recurrence, mechanism of injury (e.g.: traumatic, overuse) and severity (e.g.: mild, moderate) was gathered. Injury severity was classified retrospectively according to the player's absence from playing in matches and training sessions. [5] A specific injury diagnosis (and OSICS classification) was also described and whether it was sustained during a match or training. [12, 36] Information confirming the diagnosis (e.g.: x-ray; MRI) was given if present. [44] Variables regarding the characteristics and circumstances of injuries are explained in Table 4.

Table 3 – Variables in study (match and training exposure)

NAME	DESCRIPTION	TYPE	VARIABLE DOMAIN
Type_Sess	Type of Session (Match / Training)	Qualitative	0 = Match 1 = Training
Date_Sess	Date of Session (Day / Month / Year)	Quantitative discrete	DD/MM/YYYY Ex.: 01/05/2012
Dur_Sess	Duration of Session (minutes) (min)	Quantitative discrete	Record with no decimals. (Ex.: 90 min)
Tim_Day_Sess	Time of the Day of the Session	Qualitative	0 = 07h-09h 1 = 10h-12h 2 = 15h-17h 3 = 17h-20h 4 = 20h-22h
Session_Surf	Session's type of surface	Qualitative	0 = Natural grass 1 = 1st Generation artificial grass 2 = 2nd Generation artificial grass 3 = 3rd Generation artificial grass 4 = Running track 5 = Gym 6 = Swimming pool
Time_Exp_Tr*	Time of individual exposure (Training sessions) (minutes) (min)	Quantitative Discrete	Record with no decimals. (Ex.: 16 min)
Time_Exp_Ma*	Time of individual exposure (Matches) (minutes) (min)	Quantitative Discrete	Record with no decimals. (Ex.: 16 min)

*****One value per player

Table 4 – Variables in study (injuries)

NAME	DESCRIPTION	TYPE	VARIABLE DOMAIN
Date_inj	Date of Injury (Day / Month / Year)	Quantitative Discrete	DD/MM/YYYY Ex.: 01/05/2012
Type_Sess	Type of Session (Match / Training)	Qualitative	0 = Match 1 = Training
Type_Inj	Type of injury	Qualitative	*1 =Main Group* *1.1 = Category (OSICS)* 1 = Fractures and bone stress: 1.1 = Fracture (F) 1.2 = Other bone injuries (G, Q, S) 2 = Joint (non-bone) and ligament: 2.1 = Dislocation / subluxation (D, U) 2.2 = Sprain / ligament injury (J, L) 2.3 =Lesion of meniscus or cartilage (C) 3 = Muscle and tendon: 3.1 =Muscle rupture / tear / strain / cramps (M, Y) 3.2 = Tendon injury / rupture / tendinosis / bursitis (T, R) 4 = Contusions: 4.1 = Haematoma / contusion / bruise (H) 4.2 = Abrasion (K) 4.3 = Laceration (K) 5 = Central / peripheral nervous system: 5.1 = Concussion (with or without loss of consciousness) (N) 5.2 = Nerve injury (N) 6 = Other: 6.1 = Dental injuries (G) 6.2 = Other injuries
Loc_inj	Location of Injury	Qualitative	*1 =Main Goup* *1.1 = Category (OSICS)* 1 = Head and neck: 1.1 = Head / face (H) 1.2 = Neck / cervical spine (N) 2 = Upper limbs: 2.1 = Shoulder / scapula (S) 2.2 = Upper arm (U) 2.3 =Elbow (E) 2.4 = Forearm (R) 2.5 = Wrist (W) 2.6 = Hand / finger / thumb (P) 3 = Trunk: 3.1 = Sternum / ribs / upper back (C, D) 3.2 = Abdomen (O) 3.3 = Lower back / pelvis / sacrum (B, L) 4 = Lower limbs: 4.1 = Hip / groin (G) 4.2 = Thigh (T) 4.3 = Knee (K) 4.4 = Lower leg / Achilles tendon (Q, A) 4.5 = Ankle (A) 4.6 = Foot / toe (F)
Body_Side	Body side of injury	Qualitative	0 = Not applicable 1 = Right 2 = Left 3 = Bilateral
Mecan_inj	Mechanism of injury	Qualitative	0 = Traumatic 1 = Overuse
Sev_inj	Severity of injury	Qualitative	0 = Slight (0 days) 1 = Minimal (1-3 days) 2 = Mild (4-7 days) 3 = Moderate (8-28 days) 4 = Severe (>28 days) 5 = Career-ending
T_lost	Time lost due to injury (days)	Quantitative Discrete	Record with no decimals. (Ex.: 16 days)

3.6. Procedures

Since January, 2012 until now, an exhaustive review of the literature was done through electronic databases (e.g.: PubMed, Medscape, PEDro) and institutional libraries (if necessary) in order to properly support the study's protocol and to collect quality evidence that helps us understand the reality about the epidemiology of football injuries.

Data collection began in August, 2012 after all the needed resources for the study were acquired (authorizations from institutions, written consents from players, forms). Data collection occurred until the end of March, 2013.

A member of the medical / physiotherapy staff was always present in all the training sessions and matches, allowing the accurate completion of the individual match and training exposure forms. Immediately after an injury occurred, the injury form was completed using F-MARC concepts and terminologies, and revised if new information appeared. The medical staff was experienced in the diagnosis and treatment of football injuries. Attention was taken to use standard definitions (explained above). For each training session / match a table was filled to schematize the occurrence (or not) of injuries and session's characteristics. As stated before, only injuries acquired during team training or matches were accounted for, and injuries acquired before the beginning of the study were recorded. Player's baseline information form was completed in the beginning of the preseason and / or when a new player entered the study. The team's coaches filled in information concerning the technical aspects of training sessions and matches.

3.7. Data analysis

Data was analysed using Descriptive Statistics (Frequencies, Descriptives, and Crosstabs), such as frequency tables, percentages, central tendency (mean) and dispersion tests (standard deviation - SD). Central tendency and dispersion tests and comparison and correlation tests, parametric or non-parametric, selected according with the nature of the variables.

The software used for the data analysis was the *"Statistical Package for the Social Sciences"* (SPSS®), version 19, for Windows®. Tables and Figures were built using Microsoft® Office® 2010 (Word® and Excel®).

Percentage totals shown in tables may be subject to rounding errors associated with individual components.

3.8. Ethics

All the athletes were asked to sign a written informed consent showing their voluntary participation in the study. They were informed about the characteristics of the study and about their rights (e.g.: free to abandon study; doubt answering). Participation in this study did not interfere with the players' football career. Players were free to decide not to participate in the study without any negative consequences resulting therefrom.

The physician, head coach, assistant coach, fitness coach and goalkeeper coach were partners of the investigation team (physiotherapist). All of them gave information to be recorded and only they had authorized access to data.

Only the investigation team analysed the data. All the players were codified and treated accordingly. Only the investigation team knew the real identification of the players. Impartiality, confidentiality and anonymity were preserved. We did not incur in fraudulent practices.

Conclusions of the study are available for all the participants if they wish so.

4. RESULTS

The following results will be displayed according to the consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries, F-MARC's guidelines and this study's objectives. [12]

First, sample characterization will be done (players' age, stature, body mass, BMI, dominant leg and playing position). After this, risk exposure and training / match loads will be described. Injury prevalence, incidence, characteristics (location, body side, type, severity, recurrence, mechanism, monthly distribution) and conditions (type of surface, type of session, foul play) will also be presented. Injury consequences (session absence, team availability and injury burden) will be described.

4.1. Sample Characterization

This study's population was composed of registered male footballers from a Football Academy (VisionPro Sports Institute – VSI Rio Maior) team playing in the Portuguese 2012 / 2013 U-19 championship (Santarém district).

A total of 30 players played in the Football Academy during the study period. Eleven players were initially excluded from the sample due to participation rates of less than 20% of the study duration. All the remaining players gave their informed consent to participate in the study. Therefore, sample size for this study was 19 players. An individual coding system was used to ensure player confidentiality.

Table 5 shows the morphological characteristics of the studied players. The average player's age was 17.05 ± 0.52 years. The youngest was 16 years and the oldest 18 years. Player stature ranged from 1.70-1.89 m, with a mean value of 1.79 ± 0.05 m. The average player weighted 71.60 ± 7.90 kg, and ranged between 56.10-84.40 kg. BMI was calculated for every player. Values ranged from 18.96-25.02 kg/m^2, with a mean value of 22.25 ± 1.82 kg/m^2.

Table 5 – Sample's morphological characterization

	Season 2012 / 2013		
	Minimum	**Maximum**	**Mean ± SD**
Age (years)	16.00	18.00	17.05 ± 0.52
Stature (m)	1.70	1.89	1.79 ± 0.05
Body Mass (kg)	56.10	84.40	71.60 ± 7.90
BMI (kg/m^2)	18.96	25.02	22.25 ± 1.82

Right leg dominance was seen in most of the players (16; 84.21%). Two players (10.53%) were lefties and only one (5.26%) was ambidextrous, although he preferred the use of the right foot.

According to playing position, two players (10.53%) were goalkeepers, five (26.32%) were defenders, six (31.58%) were midfielders, and six (31.58%) were attackers.

For playing role – "mainly defensive" and "mainly attack" – players were divided in two groups, of 10 (52.63%) players (2 goalkeepers, 5 defenders and 3 defensive midfielders) and 9 (47.37%) players (6 attackers and 3 attacking midfielders), respectively.

4.2. Risk Exposure

4.2.1. Exposure Time

During the 2012 / 2013 Football Season players were exposed to a total of 3480.22 hours (h) of coached sessions. More than eighty per cent (83.83%; 2917.43 h) of these were attributed to training sessions. Match exposure was 562.78 h (16.17%) (Figure 1).

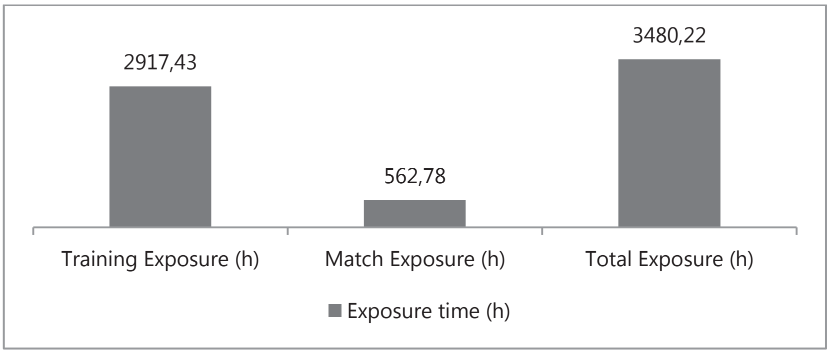

Figure 1 – Exposure times (h) for training sessions and matches

Each player was exposed to a mean of 193.17 ± 68.33 h. The minimum registered exposure was 37.92 h and the maximum was 252.58 h, corresponding to a range of 214.66 h. Every player was exposed, in average, to 153.55 ± 55.30 h of training, from 32.53 h to 219.93 h (range of 187.40 h). Match exposure showed a range of 43.67 h (minimum: 5.08 h; maximum: 48.75 h) and a mean of 29.62 ± 14.72 h of exposure (Table 6).

Table 6 – Characterization of Exposure Times (h) during the season

Type of session	Mean ± SD	Minimum	Maximum	TOTAL
Training	153.55 ± 55.30	32.53	219.93	2917.43
Match	29.62 ± 14.72	5.08	48.75	562.78
TOTAL	**193.17 ± 68.33**	**37.92**	**252.58**	**3480.22**

4.2.2. Training and Matches

During the season (August to March) 222 training sessions (86.38%) and 35 matches (13.62%) were played.

The training / match ratio throughout the season is displayed in Figure 2. A mean ratio of 7.06 has been calculated. The lowest ratio value was recorded in February (4.00) and the highest in August (14.50).

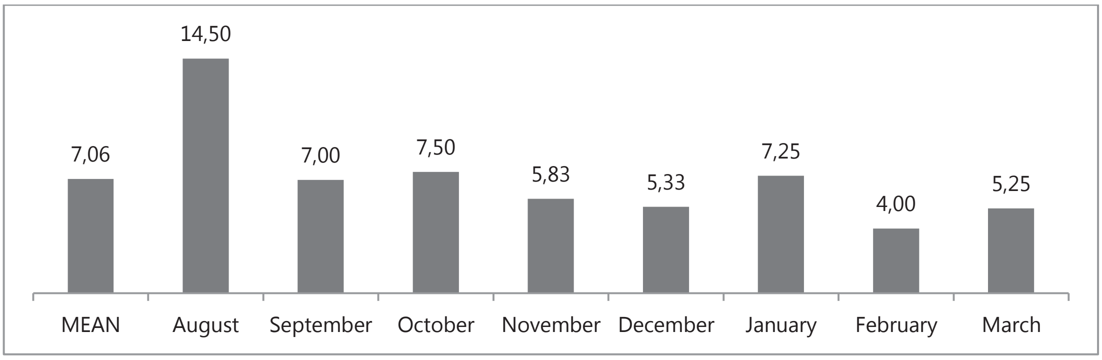

Figure 2 – Training / match's ratio throughout the season

Most training sessions occurred in the 10h-12h period (135; 60.81%), followed by the 15h-17h period of the day (84; 37.84%). More than fifty per cent (19; 54.29%) of matches occurred in the 15h-17h period.

Training sessions lasted, in average, less than an hour (0.95 h) (Table 7). The shortest and the longest training session lasted 20 and 105 minutes, respectively. Matches had 1.50 h of duration.

Table 7 – Characterization of the Duration (h) of Sessions (training and matches)

Type of Session	Mean ± SD	Minimum	Maximum	TOTAL
Training	0.95 ± 0.33	0.33	1.75	210.73
Match	1.50 ± 0.00	1.50	1.50	52.50
TOTAL	**1.02 ± 0.36**	**0.33**	**1.75**	**263.23**

All values are in hours (h)

Figure 2 illustrates the location / type of surface for both training sessions and matches. NG (149; 57.98%), gym (63; 24.51%) and 3GAT (36; 14.01%) were used in most sessions. Almost sixty per cent (130; 58.56%) of training sessions occurred in NG, followed by the gym (63; 28.38%). Up to ten per cent (21; 9.46%) of training sessions were done in 3GAT. Matches were played in NG (19; 54.29%) and 3GAT (15; 42.86%).

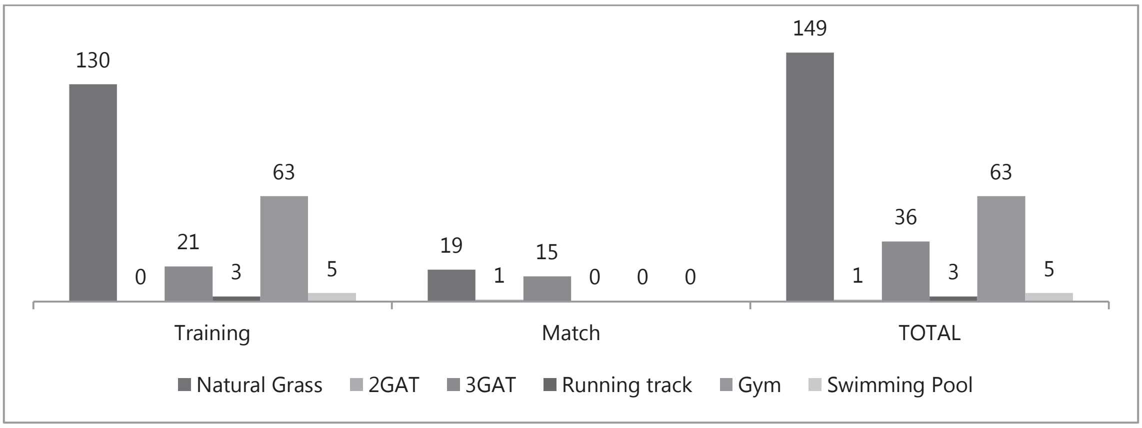

Figure 3 – Location / Type of Surface of the sessions (training and matches)

4.3. Injury Prevalence and Incidence

A total of 155 injuries were recorded during the study period (season 2012 / 2013), when a MAI definition was used. Seventy-one (45.81%) occurred in training and 84 (54.19%) during matches. If only TLI are considered, a total of 30 injuries were recorded, divided between training (13; 43.30%) and matches (17; 56.70%) (Table 8).

Table 8 – Number of injuries according to Injury Definition

Injury Definition	No. of Injuries [N (%)]		
	Total	Training	Match
Medical Attention	155 (100)	71 (45.81)	84 (54.19)
Time-Loss	30 (100)	13 (43.30)	17 (56.70)

Only one player sustained no injuries during the season. The remaining 18 players sustained at least one injury throughout the study period. Table 9 shows the distribution of players per number of recorded injuries considering both MAI and TLI definitions. MAI are evenly distributed from 1 to up to 17 injuries per player, but seven players (36.84%) suffered 7 to 10 injuries throughout the season. In average, during the season, every player sustained 8.16 MAI. TLI account for fewer injuries per player, with 7 (36.84%) players without TLI, but more than half (52.63%) acquired 1 to 3 TLI. An average of 1.58 TLI per player was calculated.

MAI prevalence (Injured players / Sample N) during this season was 94.74% (18/19). TLI prevalence was 63.16% (12/19).

Injury incidence (Injuries/1000EH) was calculated using total exposure (3480.22 h), training exposure (2917.43 h) and match exposure (562.78 h) hours, as expressed before. Table 10 describes II for both MAI and TLI.

Table 9 – Number of recorded injuries

MAI			TLI		
No. of injuries	**No. of players**	**%**	**No. of injuries**	**No. of players**	**%**
0	1	5.26	0	7	36.84
1 to 3	2	10.53	1 to 3	10	52.63
4 to 6	4	21.05	4 to 6	2	10.53
7 to 10	7	36.84			
11 to 14	3	15.79			
15 or more	2	10.53			
TOTAL	**19**	**100**	**TOTAL**	**19**	**100**

For MAI, Total II was 44.54 Injuries/1000EH (155/3480.22 x 1000), Training II was 24.34 Injuries/1000TH (71/2917.43 x 1000) and Match II was 149.26 Injuries/1000MH (84/562.78 x 1000).

If only TLI are considered, as in some existent studies, II values differ. Total II was 8.62 Injuries/1000EH (30/3480.22 x 1000), Training II was 4.46 Injuries/1000TH (13/2917.43 x 1000) and Match II was 30.21 Injuries/1000MH (17/562.78 x 1000).

Table 10 – Injury incidences (total, training, match) (Injuries/1000EH)

Injury Definition	**Injury Incidence**		
	Total	**Training**	**Match**
Medical Attention	44.54	24.34	149.26
Time-Loss	8.62	4.46	30.21

Although MAI distribution is higher in matches than in training (84 vs. 71), it is when II is calculated that this difference becomes more visible (149.26 Injuries/1000MH vs. 24.34 Injuries/1000TH). Match II is more than six times higher than training's.

For TLI, a higher number of injuries occurred in matches than in training (17 vs. 13). II also differs between matches and training (30.21 Injuries/1000MH vs. 4.46 Injuries/1000TH), up to almost seven times higher in matches than training.

For MAI (Figure 4), Total II was highest during November (8.62 Injuries/1000EH) and lowest during December (3.16 Injuries/1000EH). For training, II was highest in January (5.48 Injuries/1000TH) and lowest in December (1.37 Injuries/1000TH). Match II was lowest in March (8.88 Injuries/1000MH) but peaked in both September and November (30.21 Injuries/1000MH).

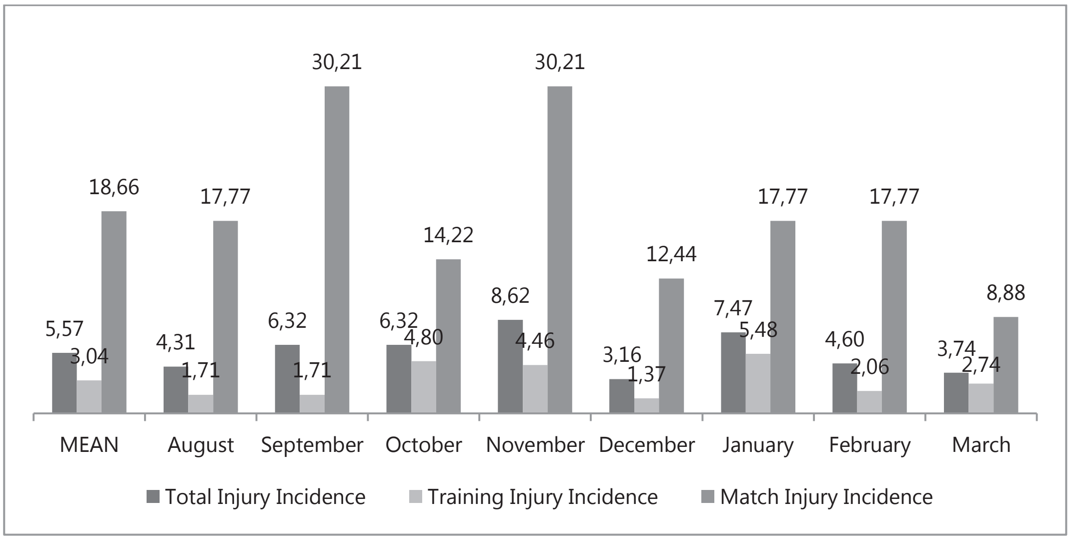

Figure 4 – Monthly distribution of Injury Incidence (Injuries/1000EH), for MAI

For TLI (Figure 5), Total II was highest in November (2.87 Injuries/1000EH) and null in March (0 Injuries/1000EH), followed by December and February (0.57 Injuries/1000EH). For training, II was highest in November (2.40 Injuries/1000TH) and no incidence of TLI was seen in September, October, February and March (0 Injuries/1000TH). Match II showed a peak in September (10.66 Injuries/1000MH) while no injuries occurred in December and March (0 Injuries/1000MH).

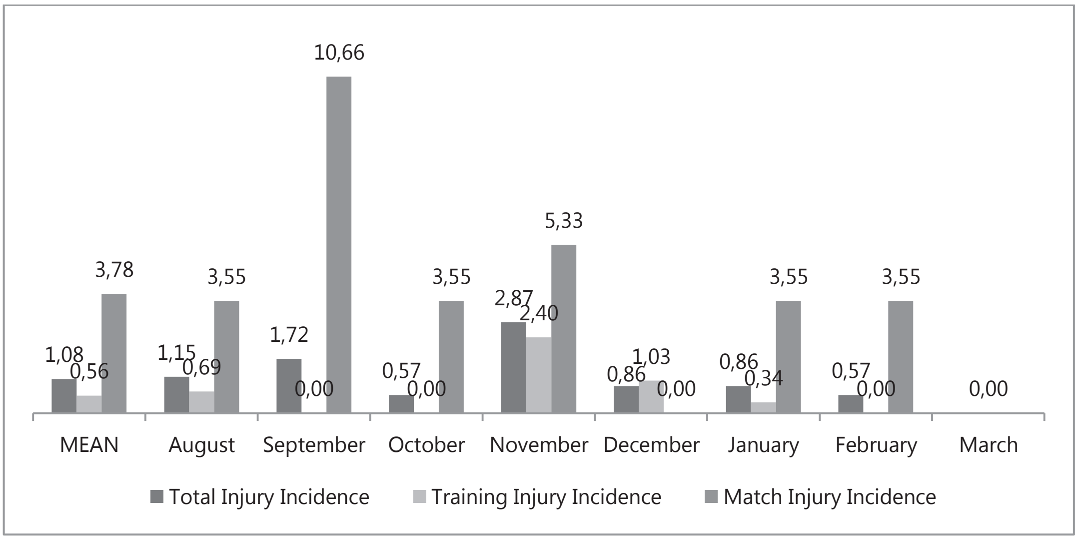

Figure 5 – Monthly distribution of Injury Incidence (Injuries/1000EH), for TLI

The football season was divided in preseason (August to mid-November) and competitive season (mid-November to March). As explained before, the season finished earlier for our team, leading to a shorter competitive season.

As shown in Table 11, 71 MAI (45.81%) were recorded during preseason (training: 27 (38.03%); matches: 44 (52.38%)) and 84 (54.19%) during competitive season (training: 44 (61.97%); matches: 40 (47.62%)). For TLI, 13 (43.33%) injuries (training: 5 (38.46%); matches: 10 (58.82%)) occurred during preseason and 17 (56.67%) (training: 8 (61.54%); matches: 7 (41.18%)) in competitive season.

Table 11 – Number of injuries [N (%)] during Preseason and Competitive Season

	MAI			TLI		
	Training	**Match**	**Total**	**Training**	**Match**	**Total**
Preseason	27 (38.03)	44 (52.38)	71 (45.81)	5 (38.46)	10 (58.82)	15 (50.00)
Competitive season	44 (61.97)	40 (47.62)	84 (54.19)	8 (61.54)	7 (41.18)	15 (50.00)
TOTAL	**71 (100)**	**84 (100)**	**155 (100)**	**13 (100)**	**17 (100)**	**30 (100)**

Table 12 shows the Training II, Match II and Total II for MAI during preseason (Training II: 20.25 Injuries/1000TH; Match II: 213.23 Injuries/1000MH; Total II: 46.69 Injuries/1000EH) and competitive season (Training II: 27.27 Injuries/1000TH; Match II: 112.22 Injuries/1000MH; Total II: 42.64 Injuries/1000EH). Training II, Match II and Total II for TLI during preseason (Training II: 3.80 Injuries/1000TH; Match II: 48.46 Injuries/1000MH; Total II: 9.86 Injuries/1000EH) and competitive season (Training II: 4.96 Injuries/1000TH; Match II: 19.64 Injuries/1000MH; Total II: 7.61 Injuries/1000EH) were also calculated.

Table 12 – Injury Incidences (Injuries/1000EH) during Preseason and Competitive Season

	MAI			TLI		
	Training	**Match**	**Total**	**Training**	**Match**	**Total**
Preseason	20.54	213.23	46.69	3.80	48.46	9.86
Competitive season	27.27	112.22	42.64	4.96	19.64	7.61
TOTAL	**24.34**	**149.26**	**44.54**	**4.46**	**30.21**	**8.62**

The number of injuries in pre and competitive seasons was relatively balanced except for preseason (more MAI / TLI occurring during matches than in training). This difference was not verified in the competitive season.

It is when we analyse II that the major differences are revealed. Although II is always higher for matches than training, in preseason, Match II is ten times higher than Training II for MAI, and almost 13 times higher than Training II (for TLI), while for the competitive season Match II is only four times higher than Training II (for both MAI and TLI).

4.4. Injury Pattern characterization

A total of 155 MAI were recorded during the study period. Seventy-one (45.81%) occurred in training and 84 (54.19%) in matches. TLI accounted for 30 injuries, divided between training (13; 43.30%) and matches (17; 56.70%) (Table 8) (Figure 6).

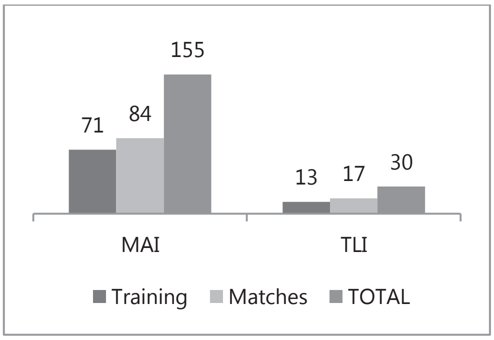

Figure 6 – Training and match injury distribution

4.4.1. Injury Location

The majority of injuries occurred in the lower limbs, for both MAI (115; 74.19%) and TLI (23; 76.67%) (Table 13). MAI were most seen in the Lower Leg / Achilles Tendon (30; 19.35%), followed by the Knee (28; 18.06%) and Thigh (23; 14.84%). The Ankle (17; 10.97%) and Low Back / Sacrum / Pelvis (16; 10.32%) were also prevalent. In the other hand, TLI mainly affected the Thigh (9; 30.00%) and Ankle (6; 20.00%).

Table 13 also presents the training / match distribution of injuries according to their location. For MAI, the Knee (13; 18.31%) was the most affected location in training, followed by the Lower Leg / Achilles Tendon (9; 12.68%) and Ankle (8; 11.27%). For matches, it were the Lower Leg / Achilles Tendon (21; 25.00%) followed by the Knee and Thigh (30; 17.86%).

Interestingly, for TLI, the most affected location in training was the Head / Face and Thigh, both with 3 injuries (23.08%), while for matches, the Thigh (6; 35.29%) appears first followed by the Ankle (5; 29.41%). This represents a different injury location pattern for MAI and TLI.

Table 13 – Distribution of injury locations in training and matches

Location	MAI						TLI					
	Training		Match		Total		Training		Match		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Head / Face	3	4.23	0	0.00	3	1.94	3	23.08	0	0.00	3	10.00
Neck / Cervical Spine	1	1.41	3	3.57	4	2.58	0	0.00	1	5.88	1	3.33
Sternum / Ribs / Upper Back	3	4.23	0	0.00	3	1.94	-	-	-	-	-	-
Abdomen	2	2.82	0	0.00	2	1.29	-	-	-	-	-	-
Low Back / Sacrum / Pelvis	5	7.04	11	13.10	16	10.32	2	15.38	1	5.88	3	10.00
Shoulder / Clavicle	2	2.82	3	3.57	5	3.23	-	-	-	-	-	-
Wrist	2	2.82	0	0.00	2	1.29	-	-	-	-	-	-
Hand / Finger / Thumb	5	7.04	0	0.00	5	3.23	-	-	-	-	-	-
Hip / Groin	5	7.04	1	1.19	6	3.87	1	7.69	0	0.00	1	3.33
Thigh	8	11.27	15	17.86	23	14.84	3	23.08	6	35.29	9	30.00
Knee	13	18.31	15	17.86	28	18.06	2	15.38	0	0.00	2	6.67
Lower Leg / Achilles Tendon	9	12.68	21	25.00	30	19.35	0	0.00	3	17.65	3	10.00
Ankle	8	11.27	9	10.71	17	10.97	1	7.69	5	29.41	6	20.00
Foot / Toe	5	7.04	6	7.14	11	7.10	1	7.69	1	5.88	2	6.67
TOTAL	**71**	**100**	**84**	**100**	**155**	**100**	**13**	**100**	**17**	**100**	**30**	**100**

4.4.2. Type of Injury

Both injury definitions showed a similar type of injury pattern, with Haematoma / Contusion / Bruise being the most common (MAI: 69, 44.50%; TLI: 8, 26.67%), followed by Muscle (Rupture / Strain / Tear / Cramps) (MAI: 35, 22.60%; TLI: 7, 23.33%) and Joint (Sprain / Ligament) injuries (MAI: 20, 12.90%; TLI: 5, 16.67%) (Table 14).

Table 14 also illustrates the training / match distribution of injuries according to their type. For MAI, the Haematoma / Contusion (Training: 23; 32.39%; Match: 46, 54.76%) was the most affected type of injury, followed by Muscle (Training: 20, 28.17%; Match: 15; 17.86%) and Joint injuries (Training: 13, 18.31%; Match: 7, 8.33%), for both training and matches.

For TLI, the most prevalent type of injury in training was the Muscle injury and the Fracture (3; 23.08%) followed by Tendon Injury (Rupture / Tendinosis / Bursitis) and Other Bone Injuries (2; 15.38%). In matches, Haematomas / Contusions (7; 41.18%), Muscle injuries (4; 23.53%) and Joint injuries (4; 23.53%) were the most common types of injury.

In a similar pattern, Haematomas / Contusions, Muscle injuries and Joint injuries are prevalent for both injury definitions (training and matches for MAI, and matches for TLI). When time-loss is taken into account Fractures and Tendon injuries show more importance in training for TLI.

Table 14 – Types of injury in training and matches

Type of Injury	MAI						TLI					
	Training		Match		Total		Training		Match		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Haematoma / Contusion	23	32.39	46	54.76	69	44.50	1	7.69	7	41.18	8	26.67
Muscle injury	20	28.17	15	17.86	35	22.60	3	23.08	4	23.53	7	23.33
Joint injury	13	18.31	7	8.33	20	12.90	1	7.69	4	23.53	5	16.67
Abrasion	4	5.63	6	7.14	10	6.50	-	-	-	-	-	-
Other bone injury	2	2.82	7	8.33	9	5.80	2	15.38	1	5.88	3	10.00
Fracture	3	4.23	1	1.19	4	2.60	3	23.08	1	5.88	4	13.33
Tendon injury	3	4.23	1	1.19	4	2.60	2	15.38	0	0.00	2	6.67
Laceration	1	1.41	1	1.19	2	1.30	-	-	-	-	-	-
Concussion	1	1.41	0	0.00	1	0.60	1	7.69	0	0.00	1	3.33
Other injury	1	1.41	0	0.00	1	0.60	-	-	-	-	-	-
TOTAL	**71**	**100**	**84**	**100**	**155**	**100**	**13**	**100**	**17**	**100**	**30**	**100**

The Concussion occurred in a training session (small-sided game) after an unintentional Contusion (knee to face) from a Goalkeeper to a Midfielder. The mechanism of injury that caused the Concussion simultaneously caused a Fracture to the supraorbital (frontal) and another on the nasal bone (confirmed by MRI). These were recorded as different injuries / diagnosis, but they were caused by the same mechanism of injury.

The following tables allow the analysis of the distribution of MAI (Table 15) and TLI (Table 16) by type and location.

The most frequent MAI were the Haematomas / Contusions to the Knee (17; 10.97%), Lower Leg / Achilles Tendon (13; 8.39%) and Thigh (12; 7.74%).

TLI pattern was different from MAI's. Thigh Muscle injuries and Ankle Joint Injuries occurred five times each, followed by Hip Haematoma / Contusion (4; 13.33%). This reveals a tendency for traumatic events, yet slight in severity, for MAI, while TLI are more Joint and Muscle injury related.

Table 15 – Distribution of Medical Attention Injuries by type and location

Location	MAI										
	Haematoma / contusion	Muscle injury	Joint injury	Abrasion	Other bone injury	Fracture	Tendon injury	Laceration	Concussion	Other injury	TOTAL
Head / Face	-	-	-	-	-	2	-	-	1	-	3
Neck / Cervical Spine	2	2	-	-	-	-	-	-	-	-	4
Sternum / Ribs / Upper Back	1	1	1	-	-	-	-	-	-	-	3
Abdomen	-	1	-	-	-	-	-	-	-	1	2
Low Back / Sacrum / Pelvis	4	7	1	-	4	-	-	-	-	-	16
Shoulder / Clavicle	4	1	-	-	-	-	-	-	-	-	5
Wrist	2	-	-	-	-	-	-	-	-	-	2
Hand / Finger / Thumb	-	-	5	-	-	-	-	-	-	-	5
Hip / Groin	-	4	-	2	-	-	-	-	-	-	6
Thigh	12	10	-	1	-	-	-	-	-	-	23
Knee	17	-	1	5	-	-	3	2	-	-	28
Lower Leg / Achilles Tendon	13	9	-	2	4	1	1	-	-	-	30
Ankle	6	-	10	-	1	-	-	-	-	-	17
Foot / Toe	8	-	2	-	-	1	-	-	-	-	11
TOTAL	**69**	**35**	**20**	**10**	**9**	**4**	**4**	**1**	**1**	**1**	**155**

Table 16 – Distribution of Time-loss Injuries by type and location

Location	TLI							
	Haematoma / contusion	Muscle injury	Joint injury	Other bone injury	Fracture	Tendon injury	Concussion	TOTAL
Head / Face	-	-	-	-	2	-	1	3
Neck / Cervical Spine	1	-	-	-	-	-	-	1
Low Back / Sacrum / Pelvis		-	-	3	-	-	-	3
Hip / Groin	-	1	-	-	-	-	-	1
Thigh	4	5	-	-	-	-	-	9
Knee	-	-	-	-	-	2	-	2
Lower Leg / Achilles Tendon	1	1	-	-	1	-	-	3
Ankle	1	-	5	-	-	-	-	6
Foot / Toe	1	-		-	1	-	-	2
TOTAL	**8**	**7**	**5**	**3**	**4**	**2**	**1**	**30**

4.4.3. Injury Side

MAI and TLI showed different patterns when it comes to side of injury (Table 17). Most MAI occurred to the left side (67; 43.23%). Right side was highly affected too (62; 40.00%). TLI were more prevalent in the right side (16; 53.33%), followed by left side injuries (9; 30.00%).

Table 17 – Injury side

	MAI		TLI	
	N	%	N	%
Right	62	40.00	16	53.33
Left	67	43.23	9	30.00
Bilateral	10	6.45	1	3.33
Not applicable	16	10.32	4	13.33
TOTAL	**155**	**100**	**30**	**100**

For MAI, the non-dominant side was the most affected (70; 45.16%), followed by the dominant (59; 38.06%). For TLI, the dominant side (17; 56.67%) was almost two times more affected than the non-dominant (8; 26.67%) (Table 18).

Table 18 – Injury side (dominant, non-dominant)

	MAI		TLI	
	N	%	N	%
Dominant	59	38.06	17	56.67
Non dominant	70	45.16	8	26.67
Bilateral	10	6.45	1	3.33
Not applicable	16	10.32	4	13.33
TOTAL	**155**	**100**	**30**	**100**

4.4.4. Mechanism of Injury

Tables 19 and 20 present injury circumstances in what concerns mechanism of injury (Trauma / Overuse) and Contact / Non-contact characteristics.

Most injuries, for both injury definitions, were traumatic (MAI: 114, 73.55%; TLI: 20, 66.67%). The remaining MAI (41; 26.45%) and TLI (10; 33.33%) were overuse injuries (Table 19).

For MAI, almost three quarters (114; 73.55%) of injuries were traumatic. Training injuries were caused by trauma in 52 (73.24%) of the cases, and by overuse in 19 (26.76%). Match injuries showed the same pattern for trauma (62; 73.81%) and overuse (22; 26.19%).

TLI showed relatively higher percentage of overuse injuries than MAI (33.33% vs. 26.45%). Seventy per cent (12) of match injuries were traumatic. Traumatic injuries in training accounted for 61.54% (8) of all injuries.

Table 19 – Injury circumstances (Trauma / Overuse)

	MAI						**TLI**					
	Training		**Match**		**TOTAL**		**Training**		**Match**		**TOTAL**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Overuse	19	26.76	22	26.19	41	26.45	5	38.46	5	29.41	10	33.33
Trauma	52	73.24	62	73.81	114	73.55	8	61.54	12	70.59	20	66.67
TOTAL	**71**	**100**	**84**	**100**	**155**	**100**	**13**	**100**	**17**	**100**	**30**	**100**

Fifty-two MAI (33.55%) were non-contact and 103 (66.45%) were due to contact. Half of all injuries resulted from contact with another player (78; 50.32%). The remaining contact injuries occurred after contact with the ball (5; 3.23%) or another object (e.g.: 3GAT surface) (20; 12.90%). Both training and match injuries were mainly due to contact with another player (Training: 33, 46.48%; Match: 45, 53.57%), followed by non-contact (Training: 27, 38.03%; Match: 25, 29.76%) (Table 20).

For TLI, half (15; 50.00%) were non-contact injuries. The other half was divided between contact with another player (13; 43.33%) and with another object (2; 6.67%). No injuries by ball contact were recorded. In training, non-contact injuries were the most prevalent (8; 61.54%), followed by contact with another player (4; 30.77%). This latter (9; 52.94%) was the most common in matches, followed by non-contact injuries (7; 41.18%) (Table 20).

Table 20 – Injury circumstances (Contact / Non-contact)

	MAI						**TLI**					
	Training		**Match**		**TOTAL**		**Training**		**Match**		**TOTAL**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
No	27	38.03	25	29.76	52	33.55	8	61.54	7	41.18	15	50.00
Yes, with another player	33	46.48	45	53.57	78	50.32	4	30.77	9	52.94	13	43.33
Yes, with the ball	3	4.23	2	2.38	5	3.23	-	-	-	-	-	-
Yes, with other object	8	11.27	12	14.29	20	12.90	1	7.69	1	5.88	2	6.67
TOTAL	**71**	**100**	**84**	**100**	**155**	**100**	**13**	**100**	**17**	**100**	**30**	**100**

Regarding Foul play (Table 21), only match injuries were considered, as referee decision only occur during matches. Match injuries accounted for 84 (54.19%) and 17 (56.70%), for MAI and TLI, respectively. Around eighty per cent of these injuries were not due to FP (MAI: 66, 78.57%; TLI: 14, 82.35%), and the remaining were (MAI: 18, 21.43%; TLI: 3, 17.65%).

Table 21 – Foul play

	MAI		TLI	
	N	**%**	**N**	**%**
No	66	78.57	14	82.35
Yes, free kick / penalty (by opponent)	18	21.43	3	17.65
TOTAL	**84**	**100**	**17**	**100**

4.4.5. Injury Severity

MAI were distributed between all the levels of injury severity. Most injuries were Slight (125; 80.65%), meaning that no absence from training / matches resulted from these injuries. The remaining injuries were Minimal (14; 9.03%), Severe (7; 4.52%), Moderate (6; 3.87%) and Mild (2; 1.29%). Only one (0.65%) Career-ending injury was recorded. It was verified that almost ninety-one per cent of injuries (141; 90.97%) resulted in less than a week of absence from training / matches (Table 22). Each MAI caused, in average, 4.75 ± 19.40 days of absence (we should remember that most injuries cause no absence from play).

TLI were the same as described above for MAI, with the exception of Slight injuries that are not considered in this injury definition. As the percentage of injury severity changes, almost half of TLI were Minimal (14; 46.67%). Severe (7; 23.33%), Moderate (6; 20.00%), Mild (2; 6.67%) and Career-ending injuries (1; 3.33%) were also recorded. Sixteen injuries (53.34%) caused less than a week of absence from play (Table 22). Each TLI caused, in average, 24.57 ± 38.67 days of absence.

Table 22 – Injury severity distribution

Severity	MAI		TLI	
	N	**%**	**N**	**%**
Slight (0 days)	125	80.65	-	-
Minimal (1-3 days)	14	9.03	14	46.67
Mild (4-7 days)	2	1.29	2	6.67
Moderate (8-28 days)	6	3.87	6	20.00
Severe (>28 days)	7	4.52	7	23.33
Career-ending	1	0.65	1	3.33
TOTAL	**155**	**100**	**30**	**100**

Table 23 shows the distribution of MAI by type and severity, revealing that the most common type of injury (Haematoma / Contusion) was mainly Slight (61) in severity.

Table 23 – Distribution of MAI by type and severity

Type of injury	Slight	Minimal	Mild	Moderate	Severe	Career-ending	TOTAL
Haematoma / Contusion	61	6	1	1	-	-	69
Muscle injury	28	2	1	2	2	-	35
Joint injury	15	4	-	1	-	-	20
Abrasion	10	-	-	-	-	-	10
Other bone injury	6	1	-	1	1	-	9
Fracture	-	-	-	-	3	1	4
Tendon injury	2	1	-	1	-	-	4
Laceration	2	-	-	-	-	-	2
Concussion	-	-	-	-	1	-	1
Other injury	1	-	-	-	-	-	1
TOTAL	**125**	**14**	**2**	**6**	**7**	**1**	**155**

The most common type of injury for TLI was again the Haematoma / Contusion (8) with Minimal severity (6) (Table 24).

Table 24 – Distribution of TLI by type and severity

Type of injury	Minimal	Mild	Moderate	Severe	Career-ending	TOTAL
Haematoma / Contusion	6	1	1	-	-	8
Muscle injury	2	1	2	2	-	7
Joint injury	4	-	1	-	-	5
Other bone injury	1	-	1	1	-	3
Fracture	-	-	-	3	1	4
Tendon injury	1	-	1	-	-	2
Concussion	-	-	-	1	-	1
TOTAL	**14**	**2**	**6**	**7**	**1**	**30**

4.4.6. Recurrences

Table 25 illustrates that both injury definitions show high percentage of non-recurrences (89.03% and 76.67% for MAI and TLI, respectively). Recurrences that occurred within two months after the player's return to full participation (Early Recurrence) accounted for 3.87% (6) and 10.00% (3) for MAI and TLI, respectively. Two (1.29%) MAI were Late Recurrences (2-12 months after return). No Late Recurrences were recorded for TLI and Delayed recurrences (>12 months after full return) were also inexistent for both injury definitions.

It should be taken into account that nine (5.81%) MAI recurrences (and four – 13.33% – TLI) gave no data regarding the date of previous injury, making it impossible to allocate them into another recurrence category (Early, Late, Delayed).

Table 25 – Injury recurrence

	MAI		TLI	
	N	**%**	**N**	**%**
Non-recurrence	138	89.03	23	76.67
Early recurrence (0-2 months)	6	3.87	3	10.00
Late recurrence (2-12 months)	2	1.29	0	0.00
Recurrence (no data)	9	5.81	4	13.33
TOTAL	**155**	**100**	**30**	**100**

MAI recurrences occurred on the medial body area (Not applicable) (7; 41.18%), left (6; 35.29%) and right (4; 23.53%) sides. The ankle (6; 35.29%), Low Back / Sacrum / Pelvis (6; 35.29%), Lower Leg / Achilles Tendon (2; 11.76%), Thigh (1; 5.88%), Foot / Toe (1; 5.88%) and Sternum / Ribs / Upper Back (1; 5.88%) were the recurrences' locations. Types of injury included Sprains / Ligament injuries (4; 23.53%), Muscle injuries (5; 29.41%), a Tendon injury (1; 5.88%), a Fracture (1; 5.88%) and other bone injuries (4; 23.53%). Recurrence severity was Slight (10; 58.82%), Minimal (3; 17.65%), Moderate (2; 11.76%), Severe (1; 5.88%) and Career-ending (1; 5.88%).

Nine (52.94%) injuries were due to overuse and eight (47.06%) to trauma. Most of them were non-contact injuries (12; 70.59%), but injuries also resulted from contact with other players (4; 23.53%) or objects (1; 5.88%). Ten (58.82%) recurrences happened in matches and seven (41.18%) in training. Recurrences were only seen on NG (8; 47.06%), 3GAT (8; 47.06%) and 2GAT (1; 5.88%). No recurrences resulted from FP.

TLI recurrences occurred on the medial body area (Not applicable) (3; 42.86%), left (2; 28.57%) and right (2; 28.57%) sides. Recurrences were located in the ankle (3; 42.86%), Low Back / Sacrum / Pelvis (3; 42.86%) and Foot / Toe (1; 14.29%). Sprains / Ligament injuries (3; 42.86%), a Fracture (1; 14.29%) and other bone injuries (3; 42.86%) were the types of injury. Recurrence severity was Minimal (3; 42.86%), Moderate (2; 28.57%), Severe (1; 14.29%) and Career-ending (1; 14.29%).

Four (57.14%) injuries were due to trauma and three (42.86%) to overuse. Most of them were non-contact injuries (5; 71.43%), but injuries also resulted from contact with other players (1; 14.29%) or objects (1; 14.29%). Four (57.14%) recurrences happened in matches and three (42.86%) in training. Recurrences were only seen on 3GAT (5; 71.43%) and NG (2; 28.57%). No recurrences resulted from FP.

4.4.7. Monthly distribution of injuries

The monthly distribution of injuries is displayed in Figures 7 and 8.

An average of 19.38 MAI occurred per month (Figure 7). A peak was seen in November (30; 19.35%), and December showed the least number of injuries (11; 7.10%). January (16; 22.54%) showed the most training MAI and October the lowest value (14; 19.72%), averaging 8.88 MAI per month. Ten and a half match MAI occurred, in average. September / November and March showed the highest (17; 20.24%) and the lowest (5; 5.95%) injury values, respectively.

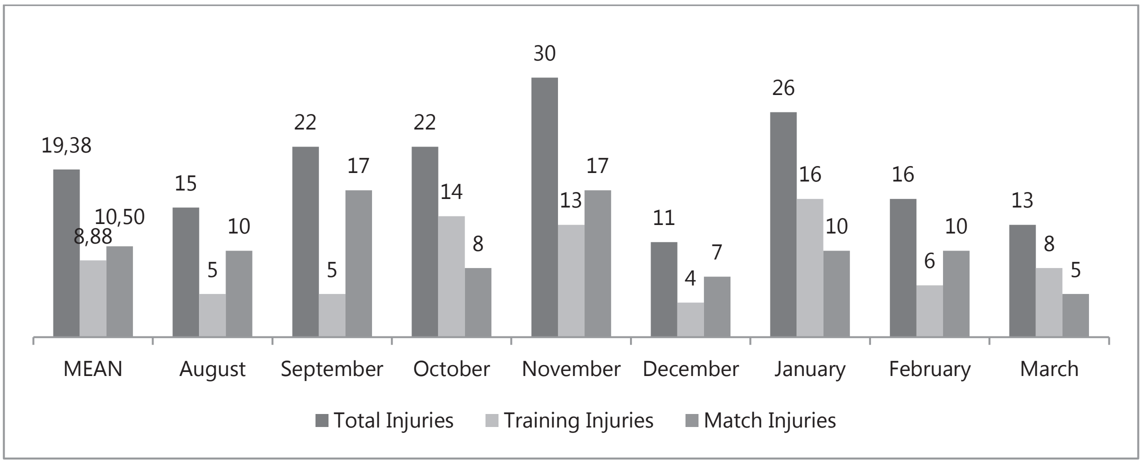

Figure 7 – Monthly distribution of MAI

An average of 1.63 and 2.13 TLI per month occurred in training and matches, respectively. November showed the highest value of injury occurrence for both total (10; 33.33%) and training (7; 53.85%) TLI. Match injuries were most seen in September (6; 35.29%). No injuries were registered in March (Figure 8).

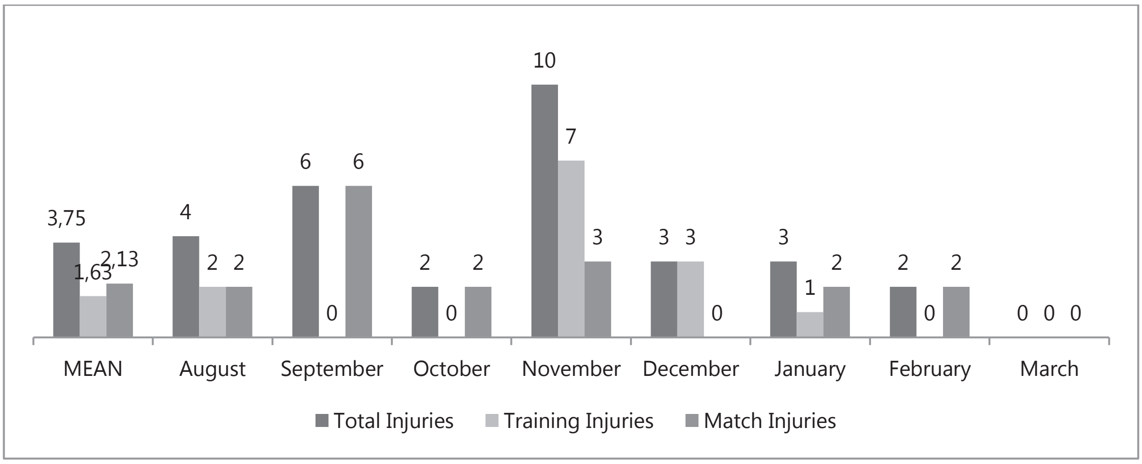

Figure 8 – Monthly distribution of TLI

As seen in Table 11, 71 (45.81%) and 84 (54.19%) MAI occurred in preseason and competitive season, respectively. For TLI, injuries were evenly distributed (15; 50.00%).

4.4.8. Playing Position / Role of injured players

The same amount of MAI (51; 32.90%) was seen in Defenders and Midfielders, followed by Attackers (41; 26.45%). Most TLI (15; 50.00%) affected Attackers, followed by Midfielders (8; 26.67%) and Defenders (7; 23.33%). Goalkeepers suffered the least number of MAI (12; 7.74%) and none TLI (Table 26).

Table 26 – Playing position / Role of injured players

	MAI		TLI	
	N	**%**	**N**	**%**
Goalkeeper	12	7.74	0	0.00
Defender	51	32.90	7	23.33
Midfielder	51	32.90	8	26.67
Attacker	41	26.45	15	50.00
TOTAL	**155**	**100**	**30**	**100**

4.4.9. Type of Surface

Table 27 shows that 90 (58.06%) MAI occurred in NG, followed by 3GAT (57; 36.77%). TLI followed the same pattern (NG: 19, 63.33%; 3GAT: 10, 33.33%). All the other surfaces used in training showed almost no injury occurrences.

Table 27 – Type of surface on which injuries occurred

	MAI		TLI	
	N	**%**	**N**	**%**
Natural grass	90	58.06	19	63.33
3GAT	57	36.77	10	33.33
2GAT	3	1.94	0	0.00
Gym	4	2.58	0	0.00
Running track	1	0.65	1	3.33
TOTAL	**155**	**100**	**30**	**100**

4.4.10. Pattern of Haematomas / Contusions, Muscle injuries and Joint injuries

It is important to characterize the types of injury that are more incident in the team (Table 28). This study shows that the most common injury type was the Haematoma / Contusions (MAI: 69, 44.50%; TLI: 8, 26.67%), followed by Muscle (MAI: 35, 22.60%; TLI: 7, 23.33%) and Joint (MAI: 20, 12.90%; TLI: 5, 16.67%) injuries. Total II were also calculated. MAI and TLI showed 19.83 and 2.30 Injuries/1000EH for Haematomas / Contusions (MAI: 69/3480.22 x 1000; TLI: 8/3480.22 x 1000), 10.06 and 2.01 Injuries/1000EH for Muscle injuries (MAI: 35/3480.22 x 1000; TLI: 7/3480.22 x 1000), and 5.75 and 1.44 Injuries/1000EH for Joint injuries (MAI: 20/3480.22 x 1000; TLI: 5/3480.22 x 1000), respectively.

Table 28 – Characteristics of most common types of injury

Type of injury	MAI			TLI		
	N	% (of total)	Injury Incidence (Injuries/1000EH)	N	% (of total)	Injury Incidence (Injuries/1000EH)
Haematomas / Contusions	69	44.50	19.83	8	26.67	2.30
Muscle injuries	35	22.60	10.06	7	23.33	2.01
Joint injuries	20	12.90	5.75	5	16.67	1.44

4.4.10.1. Haematomas / Contusions

Again, most Haematomas / Contusions occurred in the lower limbs (MAI: 56, 81.16%; TLI: 7, 87.50%). The Knee (17; 24.64%) was the most affected location for MAI, followed by the Lower Leg / Achilles Tendon (13; 18.84%) and Thigh (12; 17.39%). When time-loss is considered, the thigh registers half (4; 50.00%) of the Haematomas / Contusions (Table 29).

Table 29 – Location of Haematomas / Contusions

Location	MAI		TLI	
	N	%	N	%
Neck / Cervical Spine	2	2.90	1	12.50
Sternum / Ribs / Upper Back	1	1.45	-	-
Low Back / Sacrum / Pelvis	4	5.80	-	-
Shoulder / Clavicle	4	5.80	-	-
Wrist	2	2.90	-	-
Thigh	12	17.39	4	50.00
Knee	17	24.64	-	-
Lower Leg / Achilles Tendon	13	18.84	1	12.50
Ankle	6	8.70	1	12.50
Foot / Toe	8	11.59	1	12.50
TOTAL	**69**	**100**	**8**	**100**

For MAI, Total II was 19.83 Injuries/1000EH, Training II was 7.88 Injuries/1000TH and Match II was 81.74 Injuries/1000MH. For TLI, Total II was 2.30 Injuries/1000EH, Training II was 0.34 Injuries/1000TH and Match II was 12.44 Injuries/1000MH.

For MAI, sixteen players (84.21%) were affected by the sixty-nine Haematomas / Contusions. Match injuries (46; 66.67%) were twice the training (23; 33.33%) injuries. Only one injury (1.45%) was non-contact. The remaining Haematomas / Contusions were due to contact with another player (59; 85.51%), the ball (3; 4.35%), or other object (6; 8.70%). As methodologically explained, all injuries were index injuries. For TLI, five players (26.32%) were affected by the eight Haematomas / Contusions. Only one occurred in training (12.50%).

The distribution of the severity and absence days of Haematomas / Contusions is described on Table 30. Almost ninety per cent (61; 88.41%) of MAI were slight, while 8 were of minimal (6; 8.70%), mild (1; 1.45%) and moderate (1; 1.45%) severity. Seventy-five per cent of TLI were minimal (6).

For both MAI and TLI, Haematomas / Contusions resulted in 28 days of absence from play, ranging from none to 13 days. In average, every Haematoma / Contusion caused 0.41 ± 1.71 (MAI) and 3.50 ± 4.00 (TLI) days of absence.

Table 30 – Severity of Haematomas / Contusions

Injury Severity	MAI				TLI			
	N	**%**	**Total days**	**Mean ± SD**	**N**	**%**	**Total days**	**Mean ± SD**
Slight (0 days)	61	88.41	0	0.00 ± 0.00	-	-	-	-
Minimal (1-3 days)	6	8.70	11	1.83 ± 0.98	6	75.00	11	1.83 ± 0.98
Mild (4-7 days)	1	1.45	4	4.00 ± 0.00	1	12.50	4	4.00 ± 0.00
Moderate (8-28 days)	1	1.45	13	13.00 ± 0.00	1	12.50	13	13.00 ± 0.00
TOTAL	**69**	**100**	**28**	**0.41 ± 1.71**	**8**	**100**	**28**	**3.50 ± 4.00**

For MAI, more Haematomas / Contusions were seen in the competitive season (40; 57.97%), while for TLI the same amount of injuries occurred in preseason and competitive season (4; 50.00%).

4.4.10.2. Muscle injuries

The majority of Muscle injuries occurred in the lower limbs (MAI: 23, 65.71%; TLI: 7, 100.00%), namely the thigh (MAI: 10, 28.57%; TLI: 5, 71.43%). The Lower Leg / Achilles Tendon also showed a high presence of Muscle injuries (9; 25.71%), for MAI (Table 31).

Table 31 – Location of Muscle injuries

Location	MAI		TLI	
	N	%	N	%
Neck / Cervical Spine	2	5.71	-	-
Sternum / Ribs / Upper Back	1	2.86	-	-
Abdomen	1	2.86	-	-
Low Back / Sacrum / Pelvis	7	20.00	-	-
Shoulder / Clavicle	1	2.86	-	-
Hip / Groin	4	11.43	1	14.29
Thigh	10	28.57	5	71.43
Lower Leg / Achilles Tendon	9	25.71	1	14.29
TOTAL	**35**	**100**	**7**	**100**

For MAI, Total II was 10.06 Injuries/1000EH, Training II was 6.86 Injuries/1000TH and Match II was 26.65 Injuries/1000MH. For TLI, Total II was 2.01 Injuries/1000EH, Training II was 1.03 Injuries/1000TH and Match II was 7.11 Injuries/1000MH.

Fourteen players (73.68%) were affected by the thirty-five Muscle MAI, divided between training (20; 57.14%) and match (15; 42.86%) injuries. Only two (5.71%) were due to contact with another player, while the remaining (33; 94.29%) were non-contact injuries. Five (14.29%) Muscle injuries were recurrences and 30 (85.71%) were index injuries.

For TLI, five players (26.32%) were affected by the seven Muscle injuries. Of these, four (57.14%) occurred in matches and three (42.86%) in training. All of them were non-contact injuries and index injuries.

Table 32 shows the distribution of the severity and absence days for Muscle injuries. Eighty per cent (28) of MAI were slight. The remaining MAI / TLI were evenly distributed through minimal, moderate, severe (MAI: 2, 5.71%; TLI: 2, 28.57%), and mild (MAI: 1, 2.86%; TLI: 1, 14.29%) severity.

For both MAI and TLI, Muscle injuries resulted in 117 days of absence from play, ranging from none to 50 days. In average, every Muscle injury caused 3.34 ± 10.19 (MAI) and 16.71 ± 18.11 (TLI) days of absence.

Table 32 – Severity of Muscle injuries

Injury Severity	MAI				TLI			
	N	%	Total days	Mean ± SD	N	%	Total days	Mean ± SD
Slight (0 days)	28	80.00	0	0.00 ± 0.00	-	-	-	-
Minimal (1-3 days)	2	5.71	2	1.00 ± 0.00	2	28.57	2	1.00 ± 0.00
Mild (4-7 days)	1	2.86	4	4.00 ± 0.00	1	14.29	4	4.00 ± 0.00
Moderate (8-28 days)	2	5.71	31	15.50 ± 4.95	2	28.57	31	15.50 ± 4.95
Severe (>28 days)	2	5.71	80	40.00 ± 14.14	2	28.57	80	40.00 ± 14.14
TOTAL	**35**	**100**	**117**	**3.34 ± 10.19**	**7**	**100**	**117**	**16.71 ± 18.11**

For MAI, almost two thirds (23; 65.71%) of all Muscle injuries occurred in the preseason. This difference is even higher for TLI, with 85.71% of preseason Muscle injuries.

4.4.10.3. Joint injuries

Joint injuries include both joint sprains and ligament injuries. For MAI, almost two thirds of Joint injuries were in the lower limbs (13; 65.00%). The Ankle (10; 50.00%) and the Hand / Finger / Thumb (5; 25.00%) were the most affected locations. All of TLI occurred in the Ankle (5; 100.00%) (Table 33).

Table 33 – Location of Joint injuries

Location	MAI		TLI	
	N	%	N	%
Sternum / Ribs / Upper Back	1	5.00	-	-
Low Back / Sacrum / Pelvis	1	5.00	-	-
Hand / Finger / Thumb	5	25.00	-	-
Knee	1	5.00	-	-
Ankle	10	50.00	5	100.00
Foot / Toe	2	10.00	-	-
TOTAL	**20**	**100**	**5**	**100**

For MAI, Total II was 5.75 Injuries/1000EH, Training II was 4.46 Injuries/1000TH and Match II was 12.44 Injuries/1000MH. For TLI, Total II was 1.44 Injuries/1000EH, Training II was 0.34 Injuries/1000TH and Match II was 7.11 Injuries/1000MH.

For MAI, eight players (42.11%) were affected by the twenty Joint injuries. Match injuries (7; 35.00%) were almost half the training (13; 65.00%) injuries. Four Joint injuries (20.00%) were non-contact. The remaining were due to contact with another player (9; 45.00%), the ball (2; 10.00%), or other object (5; 25.00%). Six injuries (30.00%) were recurrences, and the remaining fourteen (70.00%) were index injuries.

For TLI, five Joint injuries were sustained by four players (21.05%). Three of them (60.00%) were recurrences and only one (20.00%) was due to non-contact. Eighty per cent (4) were match injuries and lateral ankle sprains.

Injury severity distribution and days of absence for Joint injuries are shown below (Table 34). Three fourths (15; 75.00%) of MAI were slight. The remaining were of minimal (MAI: 4, 20.00%; TLI: 4, 80.00%) or moderate (MAI: 1, 5.00%; TLI: 1, 20.00%) severity.

For both injury definitions, Joint injuries caused 20 days of absence from play, ranging from none to 13 days. Every Joint injury caused 1.00 ± 2.92 (MAI) and 4.00 ± 5.05 (TLI) days of absence.

Table 34 – Severity of Joint injuries

Injury Severity	MAI				TLI			
	N	%	Total days	Mean ± SD	N	%	Total days	Mean ± SD
Slight (0 days)	15	75.00	0	0.00 ± 0.00	-	-	-	-
Minimal (1-3 days)	4	20.00	7	1.75 ± 0.50	4	80.00	7	1.75 ± 0.50
Moderate (8-28 days)	1	5.00	13	13.00 ± 0.00	1	20.00	13	13.00 ± 0.00
TOTAL	**20**	**100**	**20**	**1.00 ± 2.92**	**5**	**100**	**20**	**4.00 ± 5.05**

Both injury definitions showed a similar trend regarding season distribution of Joint injuries. The competitive season (MAI: 13, 65.00%; TLI: 3, 60.00%) had a higher number of injuries than preseason (MAI: 7, 35.00%; TLI: 2, 40.00%).

4.4.11. Pattern of Moderate, Severe and Career-ending injuries

Along with the type of injury, its' severity is an important indicator of the negative effect of an injury to a player and / or club. For this reason, a specific analysis will also be done for Moderate (8-28 days of absence) and Severe (>28 days of absence) injuries (Table 35).

For these specific injury severities, the most common was the Severe (MAI: 7, 4.52%; TLI: 7, 23.33%), followed by the Moderate (MAI: 6, 3.87%; TLI: 6, 20.00%). Total Injury Severity Incidences were also calculated. Both MAI and TLI showed 2.01 Severe Injuries/1000EH (MAI / TLI: 7/3480.22 x 1000) and 1.72 Moderate Injuries/1000EH (MAI / TLI: 6/3480.22 x 1000).

Table 35 – Characteristics of most common injury severity

Severity	MAI			TLI		
	N	% (of total)	Injury Incidence (Injuries/1000EH)	N	% (of total)	Injury Incidence (Injuries/1000EH)
Moderate (8-28 days)	6	3.87	1.72	6	20.00	1.72
Severe (>28 days)	7	4.52	2.01	7	23.33	2.01
Career-ending	1	0.65	0.29	1	3.33	0.29

4.4.11.1. Moderate injuries

Only one (16.67%) Moderate injury didn't occur in the lower limbs. The rest (5; 83.33%) affected the Thigh, Ankle and Knee joints (Table 36).

Table 36 – Location of moderate injuries

Location	MAI / TLI	
	N	%
Low Back / Sacrum / Pelvis	1	16.67
Thigh	2	33.33
Knee	1	16.67
Ankle	2	33.33
TOTAL	**6**	**100**

These injuries affected six players (31.58%), equally divided between training and matches. While most of them were non-contact injuries (5; 83.33%), half (3; 50.00%) were traumatic. Only one third (2; 33.33%) of Moderate injuries were recurrences.

Moderate injuries caused 108 days of absence from play (from 12 to 28 days). Every Moderate injury caused an average of 18.00 ± 6.51 days of absence. Most days of absence (31) were due to Muscle injuries. Regarding Moderate injuries, a third of them were Muscle injuries (2; 33.33%). All the remaining injuries were equally distributed (1; 16.67%) (Table 37).

Table 37 – Type of moderate injuries

Type of Injury	MAI / TLI					
	N	%	Minimum	Maximum	Total days	Mean ± SD
Haematoma / Contusion / Bruise	1	16.67	13	13	13	13.00 ± 0.00
Muscle injury	2	33.33	12	19	31	15.50 ± 4.95
Joint injury	1	16.67	13	13	13	13.00 ± 0.00
Other bone injury	1	16.67	28	28	28	28.00 ± 0.00
Tendon injury	1	16.67	23	23	23	23.00 ± 0.00
TOTAL	**6**	**100**	**12**	**28**	**108**	**18.00 ± 6.51**

The competitive season showed twice (4; 66.67%) the Moderate injuries than preseason (2; 33.33%).

4.4.11.2. Severe injuries

In this case, the upper body was the most affected location (4; 57.14%). The Head (3; 42.86%) was followed by the Thigh (2; 28.57%) as the most prevalent locations for Severe injuries.

These injuries affected four players (21.05%). Training injuries (4; 57.14%) were slightly more prevalent than match injuries (3; 42.86%). An IR of 0.2 injuries per match was calculated. Most injuries resulted from contact with another player (4; 57.14%), while the remaining were non-contact (3; 42.86%). The same pattern occurred for traumatic (4; 57.14%) and overuse (3; 42.86%) injuries. Only one Severe injury was a recurrence (14.29%).

As Table 38 states, Severe injuries caused 488 days of absence from play (from 30 to 166 days). A mean of 69.71 ± 46.37 days of absence was sustained by every Severe injury. Fractures were responsible for the most absence days (266 days). Most injuries were Fractures (3; 42.86%) and Muscle injuries (2; 28.57%).

Table 38 – Type of Severe injuries

Type of injury	MAI / TLI					
	N	%	Minimum	Maximum	Total days	Mean ± SD
Muscle injury	2	28.57	30	50	80	40.00 ± 14.14
Other bone injury	1	14.29	92	92	92	92.00 ± 0.00
Fracture	3	42.86	50	166	266	88.67 ± 66.97
Concussion	1	14.29	50	50	50	50.00 ± 0.00
TOTAL	**7**	**100**	**30**	**166**	**488**	**69.71 ± 46.37**

Most Severe injuries occurred during preseason (4; 57.14%).

4.4.11.3. Career-ending injuries

Only one career-ending injury was recorded. This traumatic injury, an early recurrence, was a non-contact fracture of the right 5th metatarsal bone. Occurred in December (competitive season) during a training session, and caused 111 days of absence from sessions (counted until the end of the study period). Surgery was required and the player decided to finish his football career.

4.5. Injury consequences in sports practice

Injury consequences affect players and clubs. When time-loss is considered (TLI), it may range from a single missed training session or match to a whole season of player unavailability. This can be objectively quantified by injury severity (days of absence from play due to injury, or other reasons), team availability and, ultimately, injury burden.

4.5.1. Absence due to injury

Table 39 shows that, throughout the season, a total of 820 absences (due to injury) from training / matches were recorded, averaging 43.16 ± 63.60 absences per player. A mean of 37.37 ± 54.96 training absences per player occurred, totalizing 710 absences (86.59%). For matches, 110 absences (13.41%) occurred (average of 5.79 ± 8.66 match absences per player).

Table 39 – Training / match absence due to injury

	MAI / TLI			
	Minimum	**Maximum**	**Total**	**Mean ± SD**
Training	0	186	710	37.37 ± 54.96
Matches	0	29	110	5.79 ± 8.66
TOTAL	**0**	**215**	**820**	**43.16 ± 63.60**

As Figure 9 states, an average of 102.50 (88.75 and 13.75 absences / month for training and match, respectively) absences occurred, per month. September was the month with most absences (182; 22.20%) and March with the least (35; 4.27%). Training absence followed the same pattern. Match absences were higher in November (21; 19.09%) and February (21; 19.09%) and lowest in August (5; 4.55%).

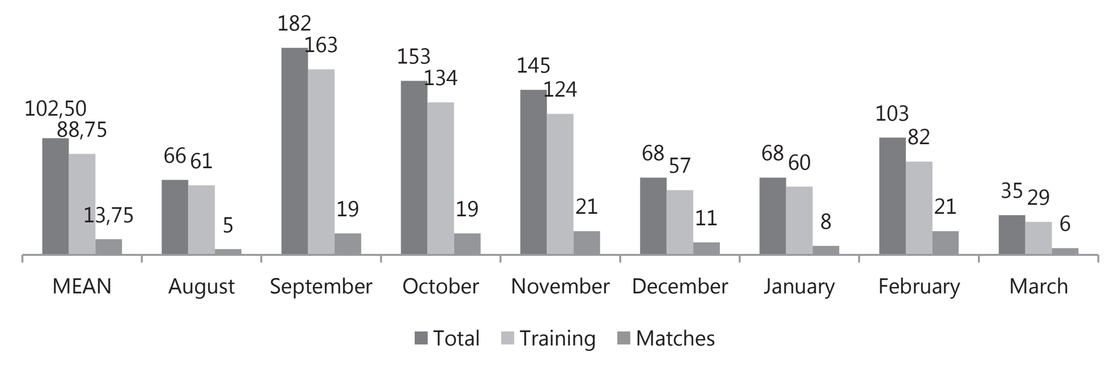

Figure 9 – Monthly distribution of training / match absence due to injury

Team absence due to injury was also calculated for both training and matches. This refers to the mean percentage of players that are injured (according to this study's injury definition), and therefore not available to participate in training and matches. Team absence due to injury is 0% if every player is available to play by not being injured (this calculation excludes those that are absent for other reasons).

Figure 10 displays the monthly distribution of team absence throughout the season. September (27.50%) was the month with the highest absence due to injury, and March (8.21%) the least. In average, 17.56% of the team did not participate in the sessions every month.

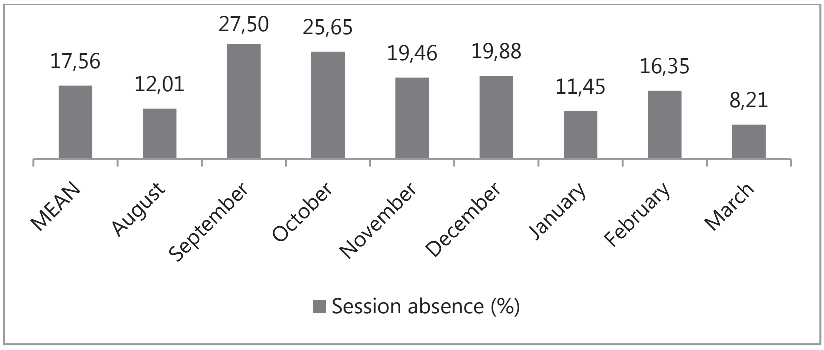

Figure 10 – Monthly distribution of team absence (%) due to injury

In average, team training (17.79%) and match (17.20%) absence due to injury showed similar results. Training team absence was highest in September (28.41%) and lowest in March (8.08%). October (26.39%) was the month where match absence due to injury showed the highest percentage, and March (8.84%) the least (Figure 11).

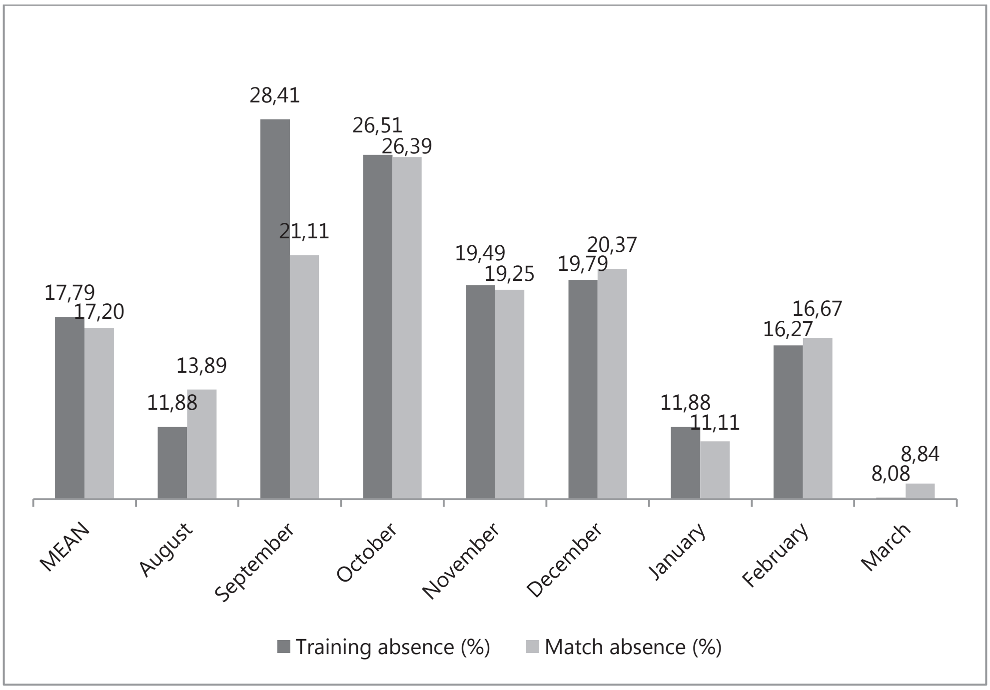

Figure 11 – Monthly distribution of team absence (%) due to injury, for training and matches

4.5.2. Absence due to illness, trial participation or others

Main absence to training and matches occurred because of sustained injuries (80.23% of absences), but the remaining 19.77% absences were due to other reasons, such as trial participation (10.08%), illness (2.45%) and others (7.24%) (Family issues, exam realization, school participation, sports injuries not included in the injury definition, out of match selection) (Table 40).

Table 40 – Training / match absence (all reasons)

Absence		MAI / TLI			
		Minimum	**Maximum**	**Total missed sessions**	**Mean ± SD**
Injury	Training	0	186	710	37.37 ± 54.96
	Matches	0	29	110	5.79 ± 8.66
	TOTAL	0	215	820	43.16 ± 63.60
Trial	Training	0	28	99	5.21 ± 8.76
	Matches	0	1	4	0.21 ± 0.42
	TOTAL	0	29	103	5.42 ± 9.01
Illness	Training	0	5	18	0.95 ± 1.81
	Matches	0	6	7	0.37 ± 1.38
	TOTAL	0	11	25	1.32 ± 2.89
Others	Training	0	26	68	3.58 ± 5.96
	Matches	0	5	6	0.32 ± 1.16
	TOTAL	0	31	74	3.89 ± 7.05
TOTAL		**0**	**215**	**1022**	**53.79 ± 59.33**

Figure 12 illustrates monthly distribution of training / match absence for every reason. In average, per month, 102.50 absences occurred due to injury (highest in September (182), lowest in March (35)), 12.88 because of trials (highest in February (54), lowest in August (0) and March (0)), 3.13 due to illnesses (highest in January (15), lowest in August (0) and October (0)), and 9.25 for other reasons (highest in March (26), lowest in August (0) and January (0)).

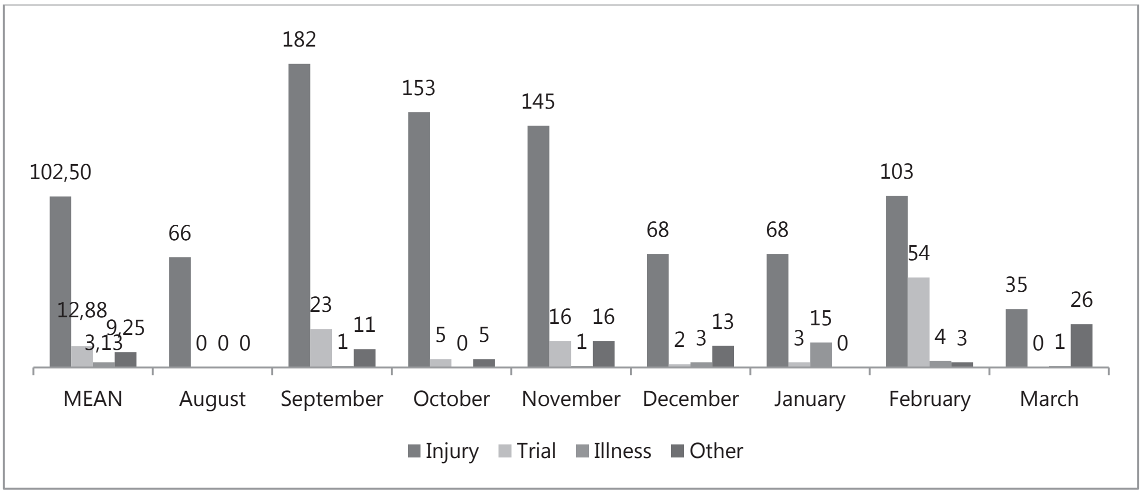

Figure 12 – Monthly distribution of training / match absences (all reasons)

4.5.3. Team availability

Team availability throughout the season is related with mean player participation in training / matches, displayed as a percentage. The higher the percentage, the more players are available.

Figure 13 illustrates team availability for the whole season. In average, 78.83% (13 to 14 players) of the team was available, per month. The month with the lowest team availability was September (70.14%) and with the highest, August (87.99%).

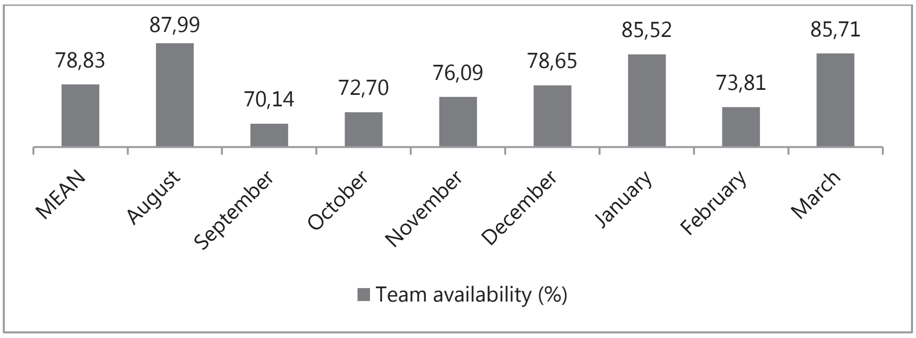

Figure 13 – Team availability (%) throughout the season

Figure 14 below shows team availability by month, for both training and matches. Mean team availability was 79.16% and 80.04% for training and matches, respectively. Availability for training was highest in January (88.31%) and lowest in September (68.73%). For matches, August was the month with the highest percentage of team availability (86.11%), and October with the least (73.61%).

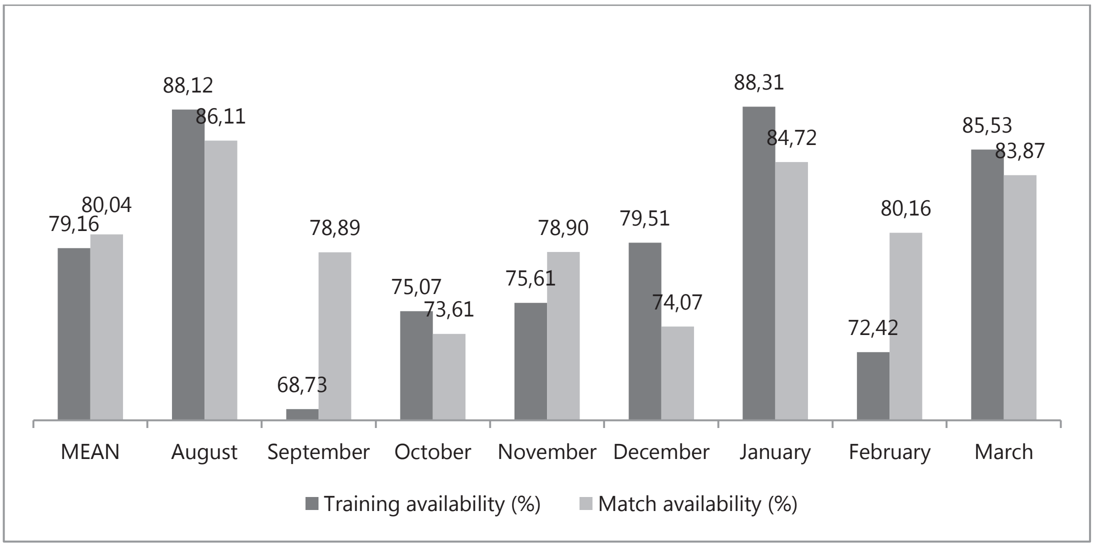

Figure 14 – Team availability (%), for training and matches

4.5.4. Training sessions and matches lost due to injury

Injury consequences should also be studied individually, for every player, by analysing the mean number of lost sessions (training and matches) throughout the season.

Every player lost, in average, 5.39 sessions (4.67 training sessions and 0.72 matches) per month, due to injury. The month where most sessions were lost was September (9.58). The least was March (1.84). Lost training sessions followed the same pattern. For matches, November and February showed the highest amount of lost sessions (1.11), while August showed the least (0.26) (Figure 15).

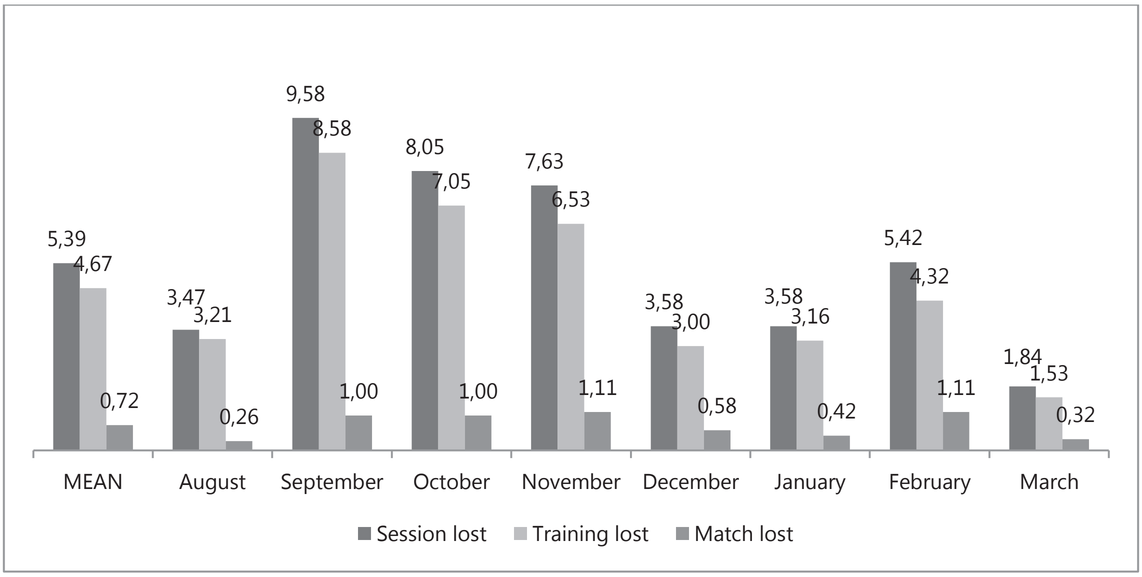

Figure 15 – Sessions lost / per player / per month, due to injury

4.5.5. Injury Burden

Injury Burden relates to a measure of injury consequence for the player / team that considers injury frequency (incidence) and severity to calculate a score. It is calculated by "(Days of Absence x 1000)/EH" and expressed as the "No. of Days of Absence/1000EH".

During this season, 30 injuries occurred, resulting in 24.57 days of absence, in average. Of these, 13 were training injuries (27.69 mean days of absence) and 17 were match injuries (22.18 mean days of absence). Training (2917.43 TH) and match (562.78 MH) exposure was recorded. Total Exposure time was 3480.22 hours. These values allow the calculation of Injury Burden (Table 41).

Table 41 – Injury Burden for training and matches

	MAI / TLI				
	Time of exposure	**No. of injuries**	**Days of absence**	**Mean days of absence**	**Injury Burden**
Training	2917.43 TH	13	360	27.69	123.40
Matches	562.78 MH	17	377	22.18	669.89
TOTAL	**3480.22 EH**	**30**	**737**	**24.57**	**211.77**

Injury Burden for matches (669.89 Days of Absence/1000EH) was more than five times higher than for training (123.40 Days of Absence/1000EH). Match injury severity was therefore higher than trainings'.

5. DISCUSSION

Our results should be critically analysed and compared with similar studies. Our epidemiological study should be also analysed methodologically.

Our study followed the recommendations of the consensus statement on injury definitions and data collection procedures specifically developed for football injuries. [9, 12] It allows the correct and uniform collection of data by the investigation teams and, consequently, comparison between studies. The quality of epidemiologic studies is related with quality in injury collection and exposure recording. Concept definition and data collection methodology have been described as the main reasons for the inability to compare studies. [12, 36]

To promote this comparability between studies, our study was of prospective cohort design, helping to reduce recall bias and errors in data recording, which are linked with non-prospective studies.

In order to obtain the information that is analysed into conclusions injury studies rely on injury recording systems. These conclusions intend to assess injury RF into adequate prevention recommendations. To properly analyse information, there are three main ways of reporting injuries in epidemiological studies [128]:

- Absolute number of injuries;
- Proportion of injuries;
- Injury incidence:

The first two don't give information on incidences (do not consider exposure time) or risk of injury, nor the association between RF and injury. They are of limited value. Injury incidence is more indicated to characterize injury occurrence as it implicates exposure to risk, however, even these values may change according to injury definition, study design [33, 37, 38, 83, 127, 129, 130], level of competition [12, 36, 37, 40, 131, 132], data collection methodology [131], analysed population / sample [128, 131, 133]. This is why a study should only be compared with studies with the same methodological characteristics (e.g.: design, definitions).

Injury definition is of major importance, as both injury definitions show advantages and disadvantages, much related with inability for study comparison. Two main injury definitions are seen in the literature.

A **Time-loss Injury (TLI)** definition, used in most studies, is associated with risk exposure and tells us about the immediate effect of an injury on the team. Also, time-loss is sport-specific, as one injury may cause absence in one sport but not in another. This injury definition is not free of error, as it has an important subjective component associated with injury. Different players might stop (or not) their practice based on a similar physical complaint. [78]

Slight injuries (that cause no absence from play) are not considered. This may not be an adequate approach because evidence shows that previous (minor) injuries predispose the player to future significant new injuries (in the same or different location). An injury not considered by this definition may be the index injury of a recurrence (usually of higher severity). [45, 47, 93, 96]

Overuse injuries are also neglected, because they don't implicate absence from play (players train, even if their performance is diminished) and cannot be linked with a specific session. In this study, overuse injuries were recorded as occurring in the session where the player first complained about it to the medical staff.

We believe that this injury definition is important for the Coaching staff, as it reports, for instance, the location of injuries that cause absence from play and lead to a decreased performance by the team (fewer players available to be picked by the coach).

A **Medical Attention Injury (MAI)** definition allows the recording of more and more complete information. Slight injuries are recorded (every injury should be considered due to its potential relation with future injuries or recurrences). Injuries are recorded even if they don't directly affect the performance of the team. Some injuries may still not be recorded (different athletes with similar injuries but different pain thresholds, may lead to one asking for a medical assessment and the other not referring anything to the medical staff). That is, minor injuries might have gone unreported and / or underestimated because players didn't need to stop completely from training, or medical attention was not necessary. [10] MAI definition would be more indicated to inform the Medical Department about injury pattern expectations for daily practice.

A difference was found, for some injury patterns, between MAI and TLI. This shows that different definitions may lead to different conclusions, for the same population / sample. As we see it, these definitions complement each other by giving different information for the two halves of the academy team and, more importantly, it would also tell us which preventive measures should be developed and implemented by both Coaching and Medical Staffs.

Our study, by using both injury definitions (MAI and TLI), allows comparison with both types of injury studies and, more importantly, between injury definitions. Although inferential statistics was not possible to apply, interesting conclusions were obtained from the analysis of the same injuries using two different injury definition approaches.

Injury severity was recorded as the number of consecutive days that have elapsed from the date of injury to the date of the player's return to full participation in training / matches. [12] We believe it was preferable because it may not be equivalent to missed sessions (different competitive levels train / play different number of times per day / week). Also, if more time exists between sessions, more easily injured players recover. If this resting time decreases, training load may cause more injuries or delay the recovery of MAI that don't require stopping time. Return to play is also subjective (comprehends player's pain threshold, motivation, medical department's conditions, and so on).

5.1. Results' discussion

This chapter follows the sequence presented in the Results' chapter. It allows the comparison between our results and the current evidence, as previously presented in the Literature Review.

When analysing epidemiological studies on football injuries it's easy to realize that results vary substantially. This is mainly due to injury definition heterogeneity, population characteristics and study design. [21]

Risk Exposure

In this study we used the same exposure forms as in UEFA injury studies. Throughout the season, Total Exposure to coached sessions was 3480.22 h, divided between Training (83.83%; 2917.43 h) and Matches (16.17%; 562.78 h). During our study period (eight months) each player was exposed to 153.55 ± 55.30 h of Training and 29.62 ± 14.72 h of Matches (Total Exposure: 193.17 ± 68.33 h), in average. Our results are below those that Ekstrand et al registered over seven seasons (2226 players from 23 teams), with an average Total Exposure of 254 ± 85 h, Training Exposure of 213 ± 71 h, and Match Exposure of 41 ± 23 h [35]. In the 2001 / 2002 season, Ekstrand et al [91] also showed different Exposure times between 65 players that played in the World Cup (Total Exposure: 293 ± 50 h; Training Exposure: 234 ± 42 h; Match Exposure: 59 ± 20 h) and those who didn't (Total Exposure: 252 ± 86 h; Training Exposure: 214 ± 72 h; Match Exposure: 38 ± 21 h). Eleven clubs (266 players) were considered. Apart from this considerable variation in the number of played matches, no difference in risk of injury was seen. But a congested calendar may lead to fatigue, thus increasing risk of injury and poor performance in the following period.

We need to be careful during this analysis, as we should not forget that our study period was less than one season. This makes us believe that if the recording had been done for the full season, this discrepancy would be less evident. Also, evidence shows that Exposure tends not to be related with injury type, recurrence and traumatic injury. [18]

Training and Matches

During the season (August to March) 222 training sessions (86.38%) and 35 matches (13.62%) were played. An average of 27.75 training sessions and 4.38 matches occurred per month. We verified that our team's training and competitive schedule was more congested than most youth football teams that played, in average, none to one match per week, and training 3 to 4 times per week [10]. Our results are much similar to those of elite footballers as recorded by Ekstrand et al [35] (average player participation in 34 ± 17 matches and 162 ± 53 training sessions each season) and Aoki et al [45] (team exposed to 30 to 44 matches annually).

Mean training / match ratio was 7.06 training sessions per match played. This is higher than what is seen in most evidence, even for professional football teams. Hagglund et al [37] presented a ratio of 5.9 in 2001 and 3.0 in 1982. Jacobson et al [134] registered a ratio of 5.0 training sessions per match. Le Gall et al [135] calculated a ratio of 4.9 for young elite French footballers.

We believe that considering pitch and gym sessions (most frequent) as training sessions caused the ratio value to rise, even though the team frequently trained twice a day and played twice a week (friendly and championship matches). These values are similar to those seen in professional senior teams. This might result in an over training of the youth players, which may predispose the player to injury (overuse or traumatic). [59, 60]

Training sessions lasted, in average, less than an hour (0.95 h) and occurred in NG (149; 57.98%), gym (63; 24.51%) and 3GAT (36; 14.01%). This is in accordance with most teams.

Injury Prevalence and Incidence

Association Football has been described as the sport with the highest risk of sustaining an injury. [16] Football injuries were the most common sports-related injuries in primary health care in the

Netherlands. [23] A peak of II has been described to occur at ages 17-18 years [21], 16-19 years [18] (48.5%, when compared with other players), or 29-30 years [68].

A total of 155 MAI were recorded during the study period. Seventy-one (45.81%) occurred in training and 54.19% in matches. A total of 30 TLI were recorded, divided between training (43.30%) and matches (56.70%). Hawkins et al [19] found that each club sustained, per season, a mean of 39.1 TLI. Football academies show a lower II in training (48%) and competition (52%) when compared with professional clubs. IR in youth national teams is also lower than in adult national teams. [5]

The distribution of injuries between training and matches is in accordance with most evidence, reporting a higher number (and II) of match injuries when compared with training. [13, 15, 19, 33-35, 44, 48, 49, 52, 53, 62, 63, 76, 78, 79, 83, 95, 98, 105, 124, 129, 131, 136-148] Higher exposure to training, balanced by the higher physical demand and exposure to matches could explain these findings. Other authors [26, 37-40, 47, 96, 134, 135, 149-151] found more training than match injuries (51% to 69.1%).

In fact, in an elite team of 25 players it is expected that 50 injuries would occur per season, with Minor severity in half of the cases (<7 days of absence from play) and Severe in eight or nine situations (>4 weeks of absence). [35]

Only one player sustained no injuries during the season. The remaining 18 players sustained at least one injury throughout the study period. Walden et al [13] pointed that 85% of the players sustain at least one injury.

Although evenly distributed, seven players (36.84%) suffered 7 to 10 MAI throughout the season. In average, every player sustained 8.16 MAI. Seven (36.84%) players suffered no TLI, but more than half (52.63%) acquired 1 to 3 TLI. An average of 1.58 TLI occurred per player. These values are similar to what was found in the literature, for MAI (1.8 injuries/player/season) [142] and TLI [5, 19, 35, 135], (0.40 [5] to 2.2 [135] injuries/player/season). An elite male football player would sustain one performance-limiting injury per year. [1, 21]

MAI prevalence (Injured players / Sample N) during this season was 94.74%. TLI prevalence was 63.16%.

MAI prevalence is higher than most studies we analysed (12% to 100%) [18, 37-39, 48, 49, 69, 124, 129, 134, 136, 137, 139, 144, 146, 147], although most studies only use Time-loss injury definition. This shows that almost every player sustains at least one MAI throughout the season, even if it doesn't involve absence from play. This emphasizes the need to promote preventive measures in order to, if not eliminate, minimize injury severity. In the Netherlands, Injury prevalence was calculated to be 27.8 in 1000 patients per year. [23]

TLI prevalence was similar to most studies on elite professional footballers. Our young athletes showed similar injury prevalence when subject to training loads similar to those of professional footballers. This has been suggested by some authors, that training / match intensity in 16-18 year olds is similar to those of adults, which would result in similar injury patterns. [52] This would mean that if physically able, 16-18 year olds might be able to play at a professional level without necessarily bad consequences in what regards to injury.

Injury Incidence (Injuries/1000EH) was calculated using total exposure (3480.22 h), training exposure (2917.43 h) and match exposure (562.78 h) hours. For both injury definitions, II follows similar pattern when compared with evidence with the same methodology.

For **MAI**, Total II was 44.54 Injuries/1000EH, Training II was 24.34 Injuries/1000TH and Match II was 149.26 Injuries/1000MH. Match II is more than six times higher than training's. Morgan et al [143] found Match II to be twelve times higher than Training II.

Our findings are above those in the literature for Total II, such as Ristolainen et al [22] (5.1 Injuries/1000EH), Morgan et al [143] (6.2 Injuries/1000EH) and Babwah et al [50] (26.5 Injuries/1000EH).

Training II was above the studies from Morgan et [143] (2.9 Injuries/1000TH), Dvorak et al [42] (7.9 Injuries/1000TH), Bayraktar et al [51] (8.08 Injuries/1000TH) and Babwah et al [50] (14.6 Injuries/1000TH).

Match II, in this study, is higher than in any other we analysed. Morgan et al [143] (35.3 Injuries/1000MH), Bayraktar et al [51] (60.6 Injuries/1000MH), Dvorak et al [42] (61.1 Injuries/1000MH), Dvorak et al [46] (68.7 Injuries/1000MH) and Babwah et al [50] (86.6 Injuries/1000MH) all registered Match II below our findings.

Babwah et al [50] states that these results on national teams are due to training characteristics (higher intensity and conditioning for players), increased competition among players (for team selection) and use of better recording systems that allow proper consideration of minor injuries by the team physician.

For **TLI**, Total II was 8.62 Injuries/1000EH, Training II was 4.46 Injuries/1000TH and Match II was 30.21 Injuries/1000MH. II is up to almost seven times higher in matches than training. Walden et al [95] found Match II to be fourteen times higher than Training II.

Our Total II is in accordance with other authors, such as Ekstrand et al [35] (8.0 Injuries/1000EH), Dupont et al [4] (8.9 Injuries/1000EH), but not with Yard et al [65] (2.34 Injuries/1000EH), Dvorak et al [42] (4.4 Injuries/1000EH), Engebretsen et al [129] (4.7 Injuries/1000EH), Le Gall et al [135] (4.8 Injuries/1000EH), Bjorneboe et al [124] (4.9 Injuries/1000EH), Arnason et al [136] (6.6 Injuries/1000EH) and Walden et al [95] (11.3 Injuries/1000EH). Other studies range between 2.3 to 14.8 Injuries/1000EH. [15] Adolescents from North America found a consistent IR of about 5 Injuries/1000EH. [65]

Training II is above most studies we analysed, such as Yard et al [65] (1.51 Injuries/1000TH), Arnason et al [136] (2.3 Injuries/1000TH), Walden et al [95] (2.4 Injuries/1000TH), Bjorneboe et al [124] (2.4 Injuries/1000TH), Engebretsen et al [129] (2.7 Injuries/1000TH), Dupont et al [4] (3.7 Injuries/1000TH), and Le Gall et al [135] (3.9 Injuries/1000TH), but below Arnason et al [137] (5.9 Injuries/1000TH) and Dvorak et al [42] (7.9 Injuries/1000TH). Other studies [4, 13, 35, 37-39, 42, 48, 49, 62, 65, 76, 79, 95, 96, 124, 129, 135-140, 144, 152] showed Training II to range between 1.51 [65] and 11.8 Injuries/1000TH.

Match II, in this study, is also above Yard et al [65] (4.26 Injuries/1000MH), Le Gall et al [135] (11.2 Injuries/1000MH), Engebretsen et al [129] (11.9 Injuries/1000MH), Bjorneboe et al [124] (17.9 Injuries/1000MH), and Arnason et al [136] (25.6 Injuries/1000MH). It is below Walden et al [95] (34.6 Injuries/1000MH), Arnason et al [137] (34.8 Injuries/1000MH), Dupont et al [4] (48.7 Injuries/1000MH) and Dvorak et al [42] (61.1 Injuries/1000MH). Walden et al [13] describes that Match II seem to increase with the playing level (highest level of play shows a maximum II of 30 Injuries/1000MH). Other studies [4, 13, 35, 37-39, 42, 48, 49, 62, 65, 76, 79, 95, 96, 98, 124, 129, 134-138, 140, 144] showed Match II to range between 4.26 [65] and 61.1 [42] Injuries/1000MH.

In the Netherlands, II was calculated to be 23.7 in 1000 patients per year. [23] Match injuries account for half to two thirds (50.4% [5], 57% [35], 60.1% [65], 63% [19]) of all recorded injuries. Similarly for mature and young footballers, Match II has been shown to increase with age and a quarter of all match unavailability has been caused by training injuries (20%). [47]

The football season was divided in preseason (August to mid-November) and competitive season (mid-November to March). As explained before, the season finished earlier for our team, leading to a shorter competitive season.

Seventy-one MAI (45.81%) were recorded during preseason and 54.19% during competitive season. For preseason, Total II was 46.69 Injuries/1000EH, Training II was 20.25 Injuries/1000TH and Match II was 213.23 Injuries/1000MH. In the competitive season, Total II was 42.64 Injuries/1000EH, Training II was 27.27 Injuries/1000TH and Match II was 112.22 Injuries/1000MH.

For TLI, 43.33% injuries occurred during preseason and 56.67% in competitive season. For preseason, Total II was 9.86 Injuries/1000EH, Training II was 3.80 Injuries/1000TH and Match II was 48.46 Injuries/1000MH. In the competitive season, Total II was 7.61 Injuries/1000EH, Training II was 4.96 Injuries/1000TH and Match II was 19.64 Injuries/1000MH.

It is when we analyse II that the major differences are revealed. Although II is always higher for matches than training, in preseason, Match II is ten times higher than Training II for MAI, and almost 13 times higher than Training II (for TLI), while for the competitive season Match II is only four times higher than Training II (for both MAI and TLI).

The number of injuries in pre and competitive seasons was relatively balanced except for preseason (more MAI / TLI occurring during matches than in training). This difference was not verified in the competitive season. Woods et al [20] found that preseason injuries accounted for 17% of total with an average IR of 0.2 per player per preseason. Walden et al [13] only found slight differences in II between preseason (8.2 Injuries/1000EH; 5.2 Injuries/1000TH; 28.6 Injuries/1000MH) and competitive season (9.7 Injuries/1000EH; 5.8 Injuries/1000TH; 30.5 Injuries/1000MH) in the UEFA Champions League. Similar results were seen for Swedish elite footballers between preseason (8.3 Injuries/1000EH; 5.7 Injuries/1000TH; 27.2 Injuries/1000MH) and competitive season (7.8 Injuries/1000EH; 5.3 Injuries/1000TH; 25.9 Injuries/1000MH). [40] Price et al [5] recorded a significant decrease in II in the periods after breaks in activity (July and December), and a peak rate both after preseason training and mid-season break. Cloke et al [141] found an injury peak at preseason and after winter break. Muscle injuries' IR has been higher in the competitive season. [41]

It has been described that younger players (17-25 years) were at higher risk of injury than older / more experienced ones (26-35+ years) during preseason. Knowledge on how to deal with physical and mental factors during this phase is suggested as an influencing factor. [20]

At preseason, players may have not yet reached appropriate fitness levels that allow them to properly withstand the particularities of competitive football. Inappropriate training program (e.g.: increased intensity) or a too intense one to allow adaptation (fatigue related) are also probable predisposing factors. [5, 13, 19, 20, 63] Woods et al also suggests the possibility of association between IR in preseason and higher training loads. [20] Fatigue is identified as a factor that could explain IR variations over the season. [41] Given the impact of such injuries on team performance, to decrease IR, appropriate preseason training (e.g.: individualised fitness programmes) and fitness programs (even during the closed season) should be implemented. [19, 20, 47]

Injury Pattern characterization

Intensive training in younger ages exposes the athletes to more risky situations. This risk of injury will predispose young players to sustain acute and overuse injuries [59, 60] Adolescent athletes are more likely to be injured than younger children. This happens because greater mass, speed and therefore power (consequence of circulating androgens) are combined with teenage impulsiveness and recklessness. [8, 60] Some authors even suggest that training / match intensity in 16-18 year olds is similar to those of adults, which would result in similar injury patterns. [52]

Injury Location

Evidence states that young children are affected by mainly upper extremity (e.g.: hand, wrist, shoulder) and head injuries, and older players tend to sustain lower extremity injuries (e.g.: ankle, knee, hamstrings). [59, 60] Football injuries are more prevalent in the ankle (16-29%) and knee (7-36%) joints and in the thigh and calf muscles. Upper leg (9-22%), lower leg (5-6%) and groin / torso (5%) are less affected. Only 3-12% of injuries are in the upper extremity. Head / facial injuries (including concussion) account for 3% of total. [1, 21]

In our study, most injuries occurred in the lower limbs, for both MAI (74.19%) and TLI (76.67%), as concluded by most authors [1, 5, 10, 12, 13, 15, 18-21, 23, 35, 38-40, 42, 43, 45, 47-49, 51, 59, 63, 83, 93, 95, 105, 124, 132, 135, 140, 142, 149, 153-158], ranging from 30.2% to 90%.

MAI were most seen in the Lower Leg / Achilles Tendon (19.35%), followed by the Knee (18.06%) and Thigh (14.84%). The Ankle (10.97%) and Low Back / Sacrum / Pelvis (10.32%) were also prevalent. Evidence states that upper extremity may be affected in up to 20% of the situations. [15] The Thigh, Knee, Ankle and Calves are often referred as the most affected locations. [1-4, 13, 35, 63] Generally, our results are below those seen in the literature [43, 51] about the Lower Leg / Achilles Tendon (11.1% [51]), Knee (15.7% [51]), Thigh (16% [43] to 25% [51]), Ankle (11.1% [51] to 17% [43]) and Low Back / Sacrum / Pelvis (6.5% [51]).

The Knee (13; 18.31%) was the most affected location in training, followed by the Lower Leg / Achilles Tendon (12.68%) and Ankle (11.27%). For matches, it were the Lower Leg / Achilles Tendon (25.00%) followed by the Knee and Thigh (17.86%). Other authors show that, in matches, lower extremity injuries accounted for 73.6% of all injuries, followed by the head / neck (10.4%), upper extremity (9.6%) and trunk (6.4%). [42]

TLI mainly affected the Thigh (30.00%) and Ankle (20.00%). This is in accordance with the literature, as the physical demands of football, particularly for the Thighs, expose the players to high-risk actions (shooting, passing and crossing actions) that, in association with other risk factors, predispose the footballer to injury. [41, 84] The Ankle, similar to the Knee, is often described as high prevalent injury location. Several studies [5, 10, 18, 38, 44, 49, 64, 65, 149] show information on Lower Leg / Achilles Tendon (3% [10] to 13% [49]), Knee (15% [38] to 21% [38]), Thigh (13% [64] to 33.3% [149]), Ankle (9% [49] to 25% [18]), Low Back / Sacrum / Pelvis (13% [49]), and Head / Face (13.7% [65]) injuries. Hip / groin injuries showed an incidence of 12-16% of all injuries. [44]

The most affected location in training was the Head / Face and Thigh, both with 3 injuries (23.08%), while for matches, the Thigh (35.29%) appears first followed by the Ankle (29.41%).

Our results are similar to the reported by Brito et al [10], for U-19, for the Thigh (33%), Ankle (29%), Knee (11%), Foot / Toe (11%), upper limbs (6%), Hip / Groin (4%), Lower leg (3%) and Head / Face (3%).

Both acute and overuse injuries are more reported in the lower extremity as a consequence of the specific loading patterns of football. [22] For instance, the thigh and knee were the most affected body locations during preseason. [10, 20] Inadequate training techniques and rehabilitation are pointed as possible causes. [20, 51]

There is a difference in injury location pattern between MAI and TLI. This shows that slight injuries, although less severe, are numerous and affect different locations than TLI, thus leading to a change in injury pattern.

MAI location pattern would be more indicated to inform the Medical Department about injury pattern expectations for daily practice, not giving so much emphasis on injury severity. TLI location pattern would report to the Coaching Staff the location of injuries that cause absence from play (more severe) and lead to a decreased performance by the team (fewer players available to be picked by the coach). It would also tell us which preventive measures should be developed and implemented by both Coaching and Medical Staffs.

This difference between injury definitions continues to exist when injury locations are separated between training and matches. We believe that this can be explained by the type of injury that is associated with the type of session (for example, players tend to sustain more traumatic injuries during matches, probably due to higher aggressiveness, anxiety and stress during the competitive season [35]).

Type of Injury

Regarding type of injury, Sprains, Strains and Contusions are referred as the most prevalent. An elite male football player would sustain one performance-limiting injury per year. [1, 21]

Both injury definitions showed a similar type of injury pattern, with Haematoma / Contusion being the most common (MAI: 44.50%; TLI: 26.67%), followed by Muscle (MAI: 22.60%; TLI: 23.33%) and Joint injuries (MAI: 12.90%; TLI: 16.67%).

Most evidence [5, 13, 19, 20, 35, 38-40, 46-49, 83, 93, 124, 134, 137, 140, 142, 144, 146, 149, 153, 156] (mainly with TLI definition) points Muscle injuries as the most frequent type of injury (5.85% to 47.2%). Previous studies revealed Joint injuries as the most common (11% to 20%) in football. [38, 40, 156]

Junge et al [43] presents Contusions (59%) as the most frequent type of injury, followed by Strains (10%) and Sprains (10%). Hagglund et al [47] recorded Muscle Strains (27%), Contusions (26%) and Ligament Sprains (25%) as the most common injuries. Other found the most common injury types to be Sprains (33.3%), Strains (13.2%) and Lacerations (6.9%). [18] Arnason et al [49] found Hamstring Strains, Groin Strains, Knee Sprains and Ankle Sprains as the most frequent injury types in elite footballers in Iceland. Yard et al [65] recorded more Ligament Sprains (26.8%), Muscle Strains (17.9%), Contusions (13.8%) and Concussions (10.8%). For Hawkins et al [19] the Thigh (67% being posterior Muscle Strains and 14% anterior), Ankle (11%), and Knee (Ligament Sprains in 39% of cases) were the most affected locations. Bayraktar et al [51] presents most common injury types (Contusion, 32.4%; Strain, 30.6%; Sprain, 21.3%; Tendon injury and Laceration / Abrasion, 5.6%; Ligament Rupture, 3.8%; and Concussion, 3.7%).

Walden et al [13] reports Thigh (61%) and Groin (21%) as the most common locations for Strains. The most common injury subtype was Thigh Strain (16%; 65% affecting the Hamstring muscles). Most Sprains occurred in the Ankles (51%) and Knees (39%). Most common diagnosis for Aoki et al [45] were Sprains, Contusions and Muscle Strains. A high incidence of Lacerations was recorded when compared with previous studies. [45] Most common diagnosis were Ankle Sprains, Contusions and Strains to the lower extremity. [19, 63]

In youth football Contusions (25-47%), Sprains (20-35%), Muscle Strains (8.25%) and Fractures / Dislocations (3-12%) are the most common types of injury. Avulsion Fracture prevalence in the Pelvis (e.g.: ischial tuberosity) is 17.7%. Head injuries in youth football have low incidence. [15] Most injuries were Strains (31%), Sprains (20%), Contusions (8%) or tissue Bruising (7%). Fewer Contusions are reported in training but the opposite occurs for Muscle Strains. Ninety per cent of Muscle Strains involved the lower limbs (Thigh, Knee, Ankle, Groin or Lower leg). [5] In the Thigh, Strain was the main injury type (79%; of these, 43% were on the anterior Thigh, and 57% on the posterior Thigh), probably due to the muscles' characteristics in the young player (incomplete development and limited shock absorption) during technical actions (e.g.: kicking, acceleration) and its' function as a stabilizer of the Pelvis. [5] Brito et al [10] reports Muscle Strains and Ligament Sprains as the most diagnosed types of injury. Muscle injuries accounted for 30% of the total and Knee injuries (including ACL injuries) for no more than 12%. Frish et al documented that the main acute injuries in youth sports are Sprains (27-48%), Strains (17-53%; mostly at the Groin, Thigh, Calf and Back regions), Fractures (2-37%; mostly at the Wrist, Foot and Ankle regions), Dislocations (0.3-30%) and Contusions (up to 50%). [8] Generally, Contusions and Strains lead the type of recorded injuries. Muscle Strains are more common in older players, while Apophysis Strains or Apophysitis occur mainly in early adolescence. [8, 60]

Haematomas / Contusions play a more important role in our study than in most studies we analysed, where Muscle injuries are the most prevalent type of injury. [53]

For MAI, the Haematoma / Contusion (Training: 32.39%; Match: 54.76%) was the most affected type of injury, followed by Muscle (Training: 28.17%; Match: 17.86%) and Joint injuries (Training: 18.31%; Match: 8.33%), for both training and matches. Dvorak et al [42] found described the most common types of injury for training (Ankle Sprain and Thigh Strain) and matches (Contusions of the Thigh and Lower leg and Thigh Strain).

For TLI, the most prevalent type of injury in training was the Muscle injury and the Fracture (23.08%) followed by Tendon Injury and Other Bone Injuries (15.38%). In matches, Haematomas / Contusions (41.18%), Muscle injuries (23.53%) and Joint injuries (23.53%) were the most common types of injury.

In a similar pattern, Haematomas / Contusions, Muscle injuries and Joint injuries are prevalent for both injury definitions (training and matches for MAI, and matches for TLI). When time-loss is taken into account Fractures and Tendon injuries show more importance in training for TLI.

In our study, Concussions showed a low prevalence (MAI: 0.60%; TLI: 3.33%) and incidence (0.29 Injuries/1000EH). This relates with Ekstrand et al [35] on Head injuries (such as Concussions, Facial Fractures, Lacerations and Eye injuries), which occurred in 2% of cases. Concussions might go underreported if the symptoms are unrecognized by the medical staff or if the athlete doesn't report voluntarily his symptoms. Frish et al [8] also recorded Concussions (0.36 Injuries/1000EH) occurrence. Concussions were accounted for 8.7% of the cases by Aoki et al. [45] Bayraktar et al [51] recorded 3.7% of concussions.

In our study, the Concussion resulted from an unintentional contact between two players. This kind of situation may occur in football, given its' physical demands as a contact sport with inevitable collisions. The use of protective equipment and change / enforcement of rules would help prevent collision forces during play that lead to Severe injuries (e.g.: fracture). [17, 18] For injury prevention in youth football, proper rule enforcement, proper coaching, adequate refereeing, discouragement and limitation of violent contact, promotion of sportsmanship and fair play should be emphasized by the coaching staff, medical team, referees and players, leading to more safety and enjoyment in football. [1, 10, 15, 33]

Hawkins et al [19] states that match injuries account for two thirds (63%) of all recorded injuries. Strains (mainly muscular), Sprains and Contusions were the most common injury types (69%). Contusions mainly occur in matches, perhaps because of the surrounding competitive atmosphere. [19] The incidence of Hamstring Strains tends to be low in preseason and three times higher in the competitive season. This high risk might be related with the high intensity of professional football, mainly during matches. [20, 35]

The most frequent MAI were the Haematomas / Contusions to the Knee (10.97%), Lower Leg / Achilles Tendon (8.39%) and Thigh (7.74%).

TLI pattern was different from MAI's. Thigh Muscle injuries and Ankle Joint Injuries occurred five times (16.67%) each, followed by Hip Haematoma / Contusion (13.33%). This reveals a tendency for traumatic events, yet Slight in severity, for MAI, while TLI are more Joint and Muscle injury related. This traumatic nature of MAI injuries are in accordance with the physical demands of football. Understandably, these are not the type of injuries that cause most absence from play.

We believe this pattern changes occurred because of injury definition. Being football a physical sport of traumatic nature, more Haematomas / Contusions were recorded when using MAI definition (even if not causing absence). This slice of injuries is not considered with a TLI definition. We recorded every MAI, even if it didn't lead to absence.

Evidence shows that the most common injury types were the Muscle Strain (mainly Hamstring Strains), Ligament Sprain and Contusion. Adductor pain / Strain, Ankle Sprains, and Medial Collateral Ligament (MCL) injuries accounted for 9%, 7% and 5% of all injuries, respectively. [35] Hip / Groin injuries affected the Adductor (64%), Hip flexor / Iliopsoas (8%), were unspecified Groin pain (5%) and Sportsman's Hernia (4%). [44]

One of the main findings in our study was that both Ankle Sprains and Hamstring Strains showed low prevalence when compared with other studies. Lateral Ankle Sprains have the highest IR (up to 1.50 Injuries/1000EH). Knee Sprains are incident in male footballers (0.14 Injuries/1000EH). [8] This might be explained by the application, by medical and coaching staff, of adequate preventive measures that are based in recent evidence, thus preventing injury. Ankle and Knee Sprains are common in youth football because of its' running and pivoting movements, sharp cutting manoeuvres, stopping and starting movements and jumps and landings on one foot. [8]

Hamstring Strains have been described as the most prevalent injury in professional elite football. Woods et al calculated that five Hamstring Strains (resulting in absence of 90 days of training and 15 matches) would occur per club per season. [34] This could be due to increased match speed and intensity. [93]

Due to its' importance, Haematomas / Contusions, Muscle injuries and Joint injuries will be further analysed below.

Injury Side

Different injury definitions showed different side of injury patterns. Most MAI occurred to the left side (43.23%). Right side was highly affected too (40.00%). The non-dominant side was the most affected (45.16%), followed by the dominant (38.06%).

TLI were more prevalent in the right side (53.33%), followed by left side injuries (30.00%). The dominant side (56.67%) was almost two times more affected than the non-dominant (26.67%).

Price et al also found that 54% of all young footballers' injuries affected the dominant side. [5] Sixty per cent of Quadriceps Strains also occurred in the dominant leg (preferred kicking leg). [53]

For TLI, this would happen because the player's dominant side is more commonly involved when tackling and being tackled, jumping, kicking, landing and turning increasing risk of injury. [5, 19] Leg dominance was found to be a RF for Quadriceps and Adductor muscle injury. The great exposure to high-risk actions (shooting, passing and crossing actions) is pointed as one of the main causes, associated with the muscle imbalances postulated by other authors. [41, 84]

Mechanism of injury

Trauma / Overuse

The mechanism of football injuries is usually trauma during contact with another player (12-28%) (e.g.: tackle or being tackled, head the ball) and / or overuse in 9-34% of the cases. [1, 21] Acute onset of injuries occurs in most of the cases. Youth players tend to get injured during tackles, while professional players sustain more injuries during running. [15]

Most injuries were traumatic (MAI: 73.55%; TLI: 66.67%) while the remaining MAI (26.45%) and TLI (33.33%) were overuse injuries.

Three quarters of MAI were traumatic. Training injuries were caused by trauma in 73.24% of the cases, and by overuse in 26.76%. Match injuries showed a similar pattern (trauma: 73.81%; overuse: 26.19%).

Two thirds of TLI were traumatic. Traumatic injuries accounted for 70.59% of match injuries and 61.54% of training injuries. We believe that the lower proportion of traumatic injuries seen in TLI (when compared with MAI) was due to the fact that most Slight injuries were traumatic (Haematomas / Contusions) and were not, therefore, recorded.

Our findings are similar to most authors that showed a high proportion of traumatic injuries, for both MAI and TLI (up to 90%) [13, 18, 23, 35, 38-40, 47, 49, 52, 53, 93, 95, 96, 98, 124, 132, 134, 136, 137, 142, 144-147, 149, 151, 159]. Other authors [38, 156] found overuse injuries to be more prevalent. Frisch et al [8] reported 10-34% overuse injuries in youth football. Ekstrand et al [35] reports 28% of overuse injuries. Others present higher percentage of overuse injuries [4, 38, 44] (73% [44] to 76.36% [4]).

Overuse Muscle injuries (34%) affected mainly the Adductors. [41] Two thirds of Muscle injuries were traumatic with acute onset. [53] Severe injuries were caused by trauma (81.5%) or overuse (18.5%). [52]

It is described that both acute and overuse injuries are more reported in the lower extremity as a consequence of the specific loading patterns of football. [22] Traumatic injuries were less severe than overuse injuries. For older players, higher level of aggressiveness and type of play are pointed as possible causes. [10] Traumatic injuries are more common during the competitive season (matches: 81%; training: 59%). [35] Overuse injuries (such as tendinopathies) are more prevalent in the preseason period, probably because preseason is mainly focused for physical training with less matches. [19, 35] Our findings on trauma / overuse and contact / non-contact injuries show the physical demand (higher contact energy, speed, body mass), aggressiveness and competitiveness that characterize football (mainly during matches). [5, 140]

Contact / Non-contact

Twenty-six to fifty-nine per cent of football injuries may occur in non-contact (e.g.: run, twist / turn, shoot, land) and 12-28% in contact situations. [1, 21] Half of injuries result from player-to-player contact. Youth players tend to get injured during tackles, while professional players sustain more injuries during running. [15]

Fifty-two MAI (33.55%) were non-contact and 66.45% were due to contact. Half of all injuries resulted from contact with another player (50.32%). The remaining contact injuries occurred after contact with the ball (3.23%) or another object (e.g.: 3GAT surface) (12.90%). Both training and match injuries were mainly due to contact with another player (Training: 46.48%; Match: 53.57%), followed by non-contact (Training: 38.03%; Match: 29.76%).

This is in accordance with recent evidence, revealing mechanism of injury for training (contact: 64.5%; non-contact: 35.5%) and matches (player contact: 40.4%; overuse: 24.0%; non-contact trauma: 23.1%; recurrence: 11.5%). [42] Also, they state that non-contact injuries proportionally increased (from 27% in 2002 to 35.5% in 2010) when compared with contact-injuries (64.5% in 2010). [42] This could be explained by the overload of the players as a consequence of the evolution of football as a health-enhancing leisure activity. Better results could be reached with the application of prevention programs (e.g.: FIFA 11+), referee education and fair-play attitudes by coaches and players. [42]

For TLI, half (50.00%) were non-contact injuries. The other half was divided between contact with another player (43.33%) and with another object (6.67%). No injuries by ball contact were recorded. In training, non-contact injuries were the most prevalent (61.54%), followed by contact with another player (30.77%). This latter (52.94%) was the most common in matches, followed by non-contact injuries (41.18%).

Our study follows the conclusions of most authors. Player-to-player contact (16.9% to 95%) [10, 16, 18, 19, 33, 48, 50, 65, 131, 137, 160] is usually the most common, followed by non-contact (14% to 91%) [16, 19, 20, 43, 65] and contact with another object (17.7% [65]). Brito et al [10] states that contact injuries (between players, ground, ball or goalpost) represented 57% of all injuries. More than 90% of Muscle injuries occurred in non-contact situations. [53] Female footballers' injuries were caused by player-to-player contact in 84% of cases. [58] Chomiak et al [52] described contact (46%) and non-contact (54%) mechanisms for Severe injuries. Joint sprains (mainly affecting the ankle) were most reported in older players as a consequence of trauma (97%) or collision or tackles with opponents (63%). [10]

For TLI, our training injuries were mainly non-contact. Match injuries were mainly due to contact, as reported by Agel et al [63] (61%). Although this difference in pattern was not verified for MAI, contact injuries were less common in training.

Non-contact injuries have been linked with young player's low skill, endurance and coordination. This emphasizes the need to apply adequate and individual preventive measures and make sure that compliance with fair play rules occur. [10, 52]

Thigh muscle injuries, common in youth football, are related with non-contact mechanisms of injury in more than 80% of cases. Muscle conditioning protocols during preseason should be emphasized in order to alter this tendency. [64] An increase by 40% in IR of the Quadriceps muscle is seen during preseason. The increased number of kicking actions during this time likely explains this finding, and eccentric exercise protocols should be implemented to prevent it. [41]

Foul play

Only match injuries were considered for Foul play. Match injuries accounted for 54.19% and 56.70%, for MAI and TLI, respectively. Around twenty per cent of these injuries were due to opponent FP (MAI: 21.43%; TLI: 17.65%). This shows that our findings are in line with most authors [1, 13, 21, 43, 45, 47, 52, 65] that found FP values between 12.2% [65] and 34% [43]. World Cups showed fewer injuries due to FP (23% in 2010 versus 61% in 2006). [42] Literature states that ACL and Ankle injuries increase with FP. [52] Five per cent of Muscle injuries are due to FP. [53] Twenty-nine per cent of injuries in female players was due to FP, showing themselves similar to male players. [58]

FP may affect injury patterns. [3] Investigation shows the association between FP and contact-related injuries. Also, low adherence to fair play policy leads an increased injury risk. [1] Side slide tackles, for example, were identified as an important cause of injuries (e.g.: tibial and fibular fractures) but it was verified that some injuries result from violent play that does not constitute FP. [63] FP-related injuries showed a gradual decrease tendency over the years [45] As a potentially preventable cause of injury, suggestions have been made to change the laws of the game focusing injury prevention (protecting players from dangerous play) and it is the referees' job to implement them. [119] Proper rule enforcement, discouragement and limitation of violent contact, promotion of sportsmanship and fair play may reduce this risk and lead to more safety and enjoyment in football. [1, 10] Aoki et al reports positive results of education on FP. [45]

Injury Severity

Injury Severity is defined as the number of consecutive days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection. [12]

The majority of youth football injuries (70-80%) are Minor or Moderate, not resulting in significant (a maximum of 7 days) absence from play. [1, 15, 21, 38]

Azubuike et al found an association between injury severity and the number of substitutions because of injuries, suggesting that a substitution after an injury can be an indicator of its severity. [18]

Most **MAI** were Slight (80.65%), meaning that no absence from training / matches resulted from these injuries. The remaining injuries were Minimal (9.03%), Severe (4.52%), Moderate (3.87%) and Mild (1.29%). One (0.65%) Career-ending injury was recorded. Almost ninety-one per cent of injuries (90.97%) resulted in less than a week of absence from training / matches, following the results of Babwah et al [50] (84%), and other authors who state that injuries that result in absence from play from 0 to 7 days may comprise from 50% to 84% of all injuries. [38, 45-48, 50]

Our findings on Slight injuries are above most authors, such as Babwah et al [50] (52%) during International Tournaments and Azubuike et al [18] (17.6%). Slight injuries (mostly Haematomas / Contusions) may be prevented by emphasizing fair-play adherence.

For Minimal injuries, our results were below most authors, such as Babwah et al [50], who showed that 25% of injuries caused only one day of absence. Other studies [18, 50, 51] range between 18.6% and 37%.

Our results were also below most studies for Mild (e.g.: 21.6% [18]), Moderate (e.g.: 28.9% [18]) and Severe injuries (6% to 16.5%) [18, 50, 52].

Slight injuries are not considered in the **TLI** definition. As the percentage of injury severity changes, almost half of TLI were Minimal (46.67%). Severe (23.33%), Moderate (20.00%), Mild (6.67%) and Career-ending injuries (3.33%) were also recorded. Sixteen injuries (53.34%) caused less than a week of absence from play, slightly above Arnason et al [49] (39.3%). Other studies [13, 38, 43, 47, 49, 62, 79, 96, 135, 138, 140, 144-146, 156, 157, 161] show values between 30% and 60%.

Our findings on Minimal injuries are above most described evidence [4, 19, 49], that record from 10% to 29%. Our study showed less Mild (23% to 30%) [4, 13, 19, 33, 39, 40, 49, 93, 140, 162] and Moderate (30% to 45%) [4, 19, 35, 48, 49, 124, 136, 151, 153] injuries, when compared with other studies.

Our results on Severe injuries are in accordance with the evidence [4, 19, 35, 47, 49, 93, 131] (11% to 23%). Walden et al [13] emphasizes that up to 87% of these injuries occur due to trauma. Also, Ekstrand et al [35] concluded that an elite football team would sustain an average of seven Severe injuries per season.

In our study, the most common type of MAI (Haematoma / Contusion) was mainly Slight in severity. With Minimal severity, the Haematoma / Contusion was the most common type of TLI.

Hip / groin injuries result in more than a week of absence in more than 50% of cases (moderate: 41%; severe: 12%). [44]

For injury severity, namely Slight injuries, no harmful effect of playing in AT was found. The effect of turf type on Minor and Moderate injuries needs to be clarified by further investigation due to inconsistent findings. Severe injuries also lack a clear pattern of effect, but they seem to occur less times when playing on AT and young female footballers seem to sustain more Severe injuries in AT. [3, 52] It is suggested that starting to train, suddenly, on a new surface allowing no adaptation from the athlete may explain why overuse injuries are more prevalent (3%) in preseason. [20]

Injury severity of the most common types of injury (Haematomas / Contusions, Muscle injuries and Joint injuries) will be further discussed below.

Recurrences

Both injury definitions show high percentage of non-recurrences (MAI: 89.03%; TLI: 76.67%). Early Recurrences (within two months after the player's return to full participation) accounted for 3.87% and 10.00% for MAI and TLI, respectively. Two (1.29%) MAI were Late Recurrences (2-12 months after return). No Late Recurrences were recorded for TLI and Delayed recurrences (>12 months after full return) were also inexistent for both injury definitions. Nine (5.81%) MAI recurrences (and 13.33% of TLI) gave no data regarding the date of previous injury, making it impossible to allocate them into another recurrence category (Early, Late, Delayed).

MAI showed a low rate of recurrence (10.97%) because most injuries were Haematomas / Contusions, which are, as described methodologically, not registered as recurrence. This is lower than what Azubuike et al [18] (38.8%) described. Others [1, 21] show recurrence rates of 20-25%.

Our TLI recurrence rate (23.33%) was not as low as some authors describe (7% [19] to 15% [13]), but higher recurrence rates (of up to 30%) have also been described in the literature. [18, 19, 26, 33, 34, 37-40, 137, 146] Fifteen per cent of Hip / Groin injuries were recurrences (other studies refer 31-50%). [44]

A difference has been found between professional clubs and football academies in terms of rate of recurrence. Price et al reported that only 3% of recurrences were recorded (mostly Strains and Sprains) in academies. This is thought to be due to the decreased pressure to return to competition from academy coaches, revealing greater education and player compliance. [5]

Most MAI recurrences affected the Ankle (35.29%), Low Back / Sacrum / Pelvis (35.29%), and Lower Leg / Achilles Tendon (11.76%), Thigh (5.88%), Foot / Toe (5.88%) and Sternum / Ribs / Upper Back (5.88%). Types of injury included Sprains / Ligament injuries (23.53%), Muscle injuries (29.41%), a Tendon injury (5.88%), a Fracture (5.88%) and other bone injuries (23.53%). Recurrence severity was Slight (58.82%), Minimal (17.65%), Moderate (11.76%), Severe (5.88%) and Career-ending (5.88%).

Nine (52.94%) injuries were due to overuse and 47.06% to trauma. Most of them were non-contact injuries (70.59%), followed by contact with other players (23.53%). Ten (58.82%) recurrences happened in matches and 41.18% in training. Recurrences were only seen on NG (47.06%), 3GAT (47.06%) and 2GAT (5.88%). No recurrences resulted from FP.

TLI recurrences were located in the Ankle (42.86%), Low Back / Sacrum / Pelvis (42.86%) and Foot / Toe (14.29%). Sprains / Ligament injuries (42.86%), a Fracture (14.29%) and other bone injuries (42.86%) were the types of injury. Recurrence severity was Minimal (42.86%), Moderate (28.57%), Severe (14.29%) and Career-ending (14.29%).

Four (57.14%) injuries were due to trauma and 42.86% to overuse. Most of them were non-contact injuries (71.43%). Four (57.14%) recurrences happened in matches and 42.86% in training. Recurrences were only seen on 3GAT (71.43%) and NG (28.57%). No recurrences resulted from FP.

Our findings are in accordance with evidence, as Strains and Sprains were the most prevalent recurrences, probably because of inadequate rehabilitation or early return to play. In our study, Muscle injuries (e.g.: Strains) affected mainly the Low Back, not the Thigh (Quadriceps: 35%; Hamstrings: 33%; Hip Adductors: 20%) as described by Price et al [5]. Hawkins et al [19] found that 66% of recurrences were lower extremity Strains (48%) or Sprains (18%). For Hagglund et al, Muscle injury recurrences accounted for 27% of total (Hamstrings, 30%; Adductors, 29%; Quadriceps, 21%; and Calf, 21%). [41] Different rates of recurrence for Hamstring Strain have been described (12% [34], 23.4% [27]). Muscle injury recurrence rate has been described as 16%. [53]

Some authors refer that absence times were similar for the recurrence and the index injury. [13, 64] Much more defend that recurrences tend to cause longer absence from play than the index injury. [19, 37-40, 44, 47, 53] For instance, each Muscle Strain recurrence lead to an average absence of 3 days and 0.4 matches per player per season. A total of 85 working days and 11 matches were lost per season, emphasizing the importance of preventive strategies. [27] Hawkins et al [19] found recurrences to cause 25.1 days of absence while index injuries only caused 19.1 absence days. Walden et al [40] recorded 10.9 and 7.6 days of absence, respectively.

For national team representation, a low recurrence rate (4% [13], 9% [47]) is seen, supporting the assumption that injured players are not selected for international duty squads in the first place. [47]

Previous identical injury was identified as an important intrinsic RF for lower extremity Muscle injuries, new injuries to the Ankle, Groin and Hamstrings. [41, 62, 69, 71, 76, 79] Previous Adductor injury is a RF for a new Adductor muscle injury. History of injury to other lower extremity muscle groups increased by 68-91% the rate of Quadriceps and Calf injury. Hamstring injuries are more probable if a previous injury occurred in the Hamstrings, Quadriceps or Calf. [41] The risk of a new Groin or Hamstring injury is more than two times higher in players with previous identical injury. [76, 79] Young elite football athletes with previous injury are more prone to Thigh Strains. [74] Cloke et al found 16-year-old players, midfielders, and Hamstring injuries more likely to sustain a recurrence. [64] This was not found to be true in our study though. Carling et al. describes that rate of recurrence was higher for matches and attackers (that show high instantaneous speed demands when the agonist concentric muscle action cannot be withstand by antagonist eccentric strength). [27]

Our recurrent Sprains were only to the ATFL, which meets the 78% of ATFL Sprains, but not the 20% MCL Sprain of Price et al [5]. They also found 24% of Ankle Sprains were recurrences. [63] For Ankle injuries the risk is higher during the first six months after injury. [62]

In order to prevent recurrences during the season, index injuries should be properly and completely rehabilitated, especially Slight / Minor ones, if not possible to prevent (given the impact it has for players and sports). [20, 56] Also, major injuries are usually preceded by minor injuries of the same type and location. [45] Risk of overall injury is 1.7-3.0 greater in footballers with history of injury. Players that got injured in the previous season are more prone to injury in the next season. [8, 39, 49, 52, 62, 69, 76, 79] Previous injuries in different muscle groups in the lower extremity may also increase IR. [41]

To reduce recurrence rates, appropriate medical support, personalized rehabilitation, prevention strategies, radiological examinations (in top clubs) and specific and modern functional testing should be implemented and emphasized. [35, 53, 83] Preseason evaluation might reduce IR by allowing the application of adequate preventive measures. [41, 82, 153] When medical staff is present, injury situations tend to be dealt with properly. Chomiak et al verified that more severe injuries received appropriate treatment, while less severe injuries tended to be underestimated or inadequately treated. [52] The importance of proper evaluation by clinicians is that it allows the prevention of compensations before returning to play, and the application of controlled rehabilitation programs with specific goals before enabling the player to return. [18, 19, 27, 34, 39, 41, 71, 80, 81]

Many reasons have been described as predisposing factors for recurrences, such as biomechanical alterations in the lower extremity, remaining deficits in physical conditioning and proprioception, movement control pattern dysfunctions due to previous injuries, psychological factors, inadequate rehabilitation and early return to play after injury. [5, 18, 19, 21, 27, 34, 39, 41, 49, 51, 52, 71, 80, 81]

Monthly distribution of injuries

An average of 19.38 MAI occurred per month. A peak was seen in November (19.35%), and December had the least number of injuries (7.10%). Most training MAI occurred in January (22.54%), and fewer in October (19.72%), averaging 8.88 MAI per month. Ten and a half match MAI occurred, in average. September / November and March showed the highest (20.24%) and the lowest (5.95%) injury values, respectively.

An average of 1.63 and 2.13 TLI per month occurred in training and matches, respectively. November showed the highest value of injury occurrence for both total (33.33%) and training (53.85%) TLI. Match injuries were most seen in September (35.29%). No injuries were registered in March.

Seventy-one (45.81%) and 54.19% MAI occurred in preseason and competitive season, respectively. For TLI, injuries were evenly distributed (50.00%). When considering the part of the season, preseason tends to show different IR when compared with the competitive season. [19, 20, 41] Injuries can be up to three times more prevalent in preseason training than regular season. [63] In our study, MAI did not follow this pattern.

MAI incidence was highest in January, and TLI incidence were highest in November (transition between preseason and competitive season), suggesting a relation with published evidence. They state that injury peaks occur in the period after summer break (preseason, usually September) and winter break (January), suggesting loss of conditioning. [64] Also, a significant decrease in II was seen in the periods after breaks in activity (July and December), and a peak rate was reported both after preseason training and a mid-season break. [5] Again, an IR peak was seen in the preseason training (July) and in the first month of competitive season (August), declining after those periods. [19, 20] Brito et al [10] reported a peak after the preseason training period (training injuries – September; match injuries – October) and after midseason break.

Playing Position / Role of injured players

Different positional roles implicate different playing characteristics. Generally, the greater the activity and covered distance during matches, the higher the risk of a musculoskeletal injury (due to increased acceleration / deceleration activity). [9, 49 15, 18]

In this study, the same amount of MAI (32.90%) was seen in Defenders and Midfielders, followed by Attackers (26.45%). Most TLI (50.00%) affected Attackers, followed by Midfielders (26.67%) and Defenders (23.33%). A different pattern of injury exists between injury definitions. Most evidence [5, 18, 34, 52, 83, 132, 149, 150, 154, 163] states that Defenders sustain most injuries followed by Midfielders. Others defend that Midfielders [62, 76, 79, 135, 138, 143, 164] or Attackers [134] are the most affected. Azubuike et al [18] showed that Defenders (34.3%) and Attackers (31.4%) registered higher II than other players. Defenders (36%) and Midfielders (35%) got injured most often than Attackers. [5] Higher incidence of lower extremity injuries are sustained by Defenders followed by Midfielders, Attackers and GK. [68] Midfielders and Attackers seem to be at higher risk of thigh Muscle injuries. [64, 114]

Our GK suffered the least number of MAI (7.74%) and none TLI. As the analysed evidence shows, GK show lower II (9.8%) than OP. [18, 132, 134, 155] GK (who perform less running, more ball reaching, and more collisions with goalposts) sustain fewer (up to 25% less) injuries than OP. They show a higher rate of upper extremity, trunk and head injuries during contact play, decreased rates of Muscle injury for all major groups of lower extremity (Quadriceps, Hamstrings, Adductors and Calves), and suffer more upper extremity injuries than OP. [5, 15, 34, 41, 45, 68]

Type of Surface

Ninety (58.06%) MAI occurred in NG, followed by 3GAT (36.77%). TLI followed the same pattern (NG: 63.33%; 3GAT: 33.33%). All the other surfaces used in training showed almost no injury occurrences.

Although evidence remains contradictory, revealing no differences on IR between turfs, some findings are described revealing that the type of turf (e.g.: NG, AT) could play a role in injury prevalence. [2, 66, 93] Several authors found no differences in IR, pattern, severity, nature or cause between AT and NG. [2, 102, 103, 105] Others refer that 24% of football injuries could be attributed to unsatisfactory playing surfaces. [3, 52] Although injury risk is similar, a tendency for more Ankle Sprains and less Quadriceps Strains on AT, and more Calf Strains on NG is present. [93]

Lacerations, Ankle injuries and Ligament and Cartilage injuries are more likely in AT when compared with NG turfs. Muscle Strains seem to occur more often in NG pitches, having AT a protective effect (of more than 90%). Rapid changes between surfaces also appear to increase risk of injury, but this needs to be further investigated. [3, 102, 103]

Hershman et al [104] compared the rate of Knee and Ankle Sprain injuries sustained on NG and 3GAT surfaces while playing in NFL 2000-2009 seasons' matches. IR of ACL Sprains and eversion Ankle Sprains was significantly higher in AT than on NG surface (67% and 31%, respectively). This was not found for MCL Sprains and inversion Ankle Sprains. [104]

Williams et al [3] found a likely increased risk of Ankle injury when playing on AT. [66] Burns and frictions are less prevalent when playing in modern high-quality artificial turf pitches. [93] No difference in IR was found between 3GAT and NG, although injury pattern differs. [66]

Injury might occur as a result of overloading the tissues. Turf's impact attenuation properties are important to prevent this. Although NG shows the best results, they depend on the turf's usage, so the authors recommend the use of a 3GAT in this matter, both in dry and wet conditions. Also, playing on AT seems to cause more fatigue in players, possibly increasing risk of injury. Higher rates of Low Back Pain are recorded among young footballers that train in artificial pitches. [3, 101, 107] Although no significant association was possible, in our study, Low Back Pain was found (clinically) to increase after training / playing in AT. Fatigue and change between surfaces has been described as a possible risk factor for this. The academy staff tried to overcome this by preparing AT matches with 2 to 3 previous training sessions in AT too. This should be further studied, as no consensus exists about this association (or others) or about the correct amount of training sessions to properly prepare players for matches in different surfaces.

To prevent lower extremity injuries and reduce risk of injury, it is important to appropriately monitor field conditions (e.g.: holes, uneven playing surface and other irregularities) as treatment on the playing ground is inexistent in more than 50% of cases. [1, 52] Preventive measures for teams that regularly train and play in AT was suggested. [3]

As dry playing surface seems to be associated with preseason's IR, it is suggest the use of irrigation systems and pitch watering and softening. [20, 108] Adequate maintenance of pitches helps preventing ankle injuries. [33] Playing in the winter months is also suggested as an injury prevention strategy. [108]

Pattern of Haematomas / Contusions, Muscle injuries and Joint injuries

Haematomas / Contusions

Haematoma / Contusion was the most common type of injury (MAI: 44.50%; TLI: 26.67%).

Most Haematomas / Contusions occurred in the lower limbs (MAI: 81.16%; TLI: 87.50%). The Knee (24.64%), Lower Leg / Achilles Tendon (18.84%) and Thigh (17.39%) were the most affected locations, for MAI. For TLI, the Thigh registers half (50.00%) of the Haematomas / Contusions.

For MAI, Total II was 19.83 Injuries/1000EH, Training II was 7.88 Injuries/1000TH and Match II was 81.74 Injuries/1000MH.

For TLI, Total II was 2.30 Injuries/1000EH, Training II was 0.34 Injuries/1000TH and Match II was 12.44 Injuries/1000MH. Arnason et al [49] described a lower Total II (1.5 Injuries/1000EH), higher Training II (0.5 Injuries/1000TH) and a much lower Match II (5.9 Injuries/1000MH) in a group of 306 elite players from the Icelandic first division. This might be explained by high competitiveness during matches (which are competitive by nature), that lead to increased physical contact among players, while during training sessions players might tend to protect themselves from contact injuries. [35]

Match injuries (66.67%) were twice the training (33.33%) injuries. One injury (1.45%) was non-contact and the remaining Haematomas / Contusions were due to contact with another player (85.51%), the ball (4.35%), or other object (8.70%). For TLI, only one occurred in training (12.50%).

Almost ninety per cent (88.41%) of MAI were Slight, while 8 were of Minimal (8.70%), Mild (1.45%) and Moderate (1.45%) severity. Seventy-five per cent of TLI were Minimal.

Haematomas / Contusions resulted in 28 days of absence from play. Every Muscle injury caused, in average, 0.41 ± 1.71 (MAI) and 3.50 ± 4.00 (TLI) days of absence.

For MAI, more Haematomas / Contusions were seen in the competitive season (57.97%), while for TLI the same amount of injuries occurred in preseason and competitive season (50.00%). With a predominant mechanism of injury (contact), we understand that this pattern occurs given the physical demands of competitive football (matches).

Muscle injuries

Muscle injuries are often described as the most common type of injury in professional football. [53] In our study, Muscle injuries were the second most prevalent type of injury (MAI: 22.60%; TLI: 23.33%). They were below those described by Hagglund et al [41] (35%) and Ekstrand et al [53] (31%).

In a team of 25 players, it is expected that 15 Muscle injuries will occur, per season, with 2 weeks of absence for each injury. [53] Another study concluded that, for the same team, 10 Muscle injuries would be expected per season. [156]

In our study, most Muscle injuries occurred in the lower limbs (MAI: 65.71%; TLI: 100.00%), namely the Thigh (MAI: 28.57%; TLI: 71.43%). For MAI, Lower Leg / Achilles Tendon Muscle injuries were also prevalent (25.71%). Other authors point that up to 92% of all Muscle injuries affect the four major muscle groups of the lower extremity (Hamstrings, 37%; Adductors, 23%; Quadriceps, 19%; and Calf muscles, 13%). [41, 53] Ekstrand et al [53] states that 12% of all Muscle injuries affect the Hamstrings. Thigh Muscle injuries are described as the most prevalent injury (13% [38] to 23% [156]) in football. Ekstrand et al [156] calculated the incidence of Thigh Muscle injury (1.6 Injuries/1000EH). For us, Thigh Muscle injuries' II was similar (1.44 Injuries/1000EH).

For MAI, Total II was 10.06 Injuries/1000EH, Training II was 6.86 Injuries/1000TH and Match II was 26.65 Injuries/1000MH.

For TLI, Total II was 2.01 Injuries/1000EH, Training II was 1.03 Injuries/1000TH and Match II was 7.11 Injuries/1000MH. Arnason et al [49] described a similar Total II (2.2 Injuries/1000EH), a slightly lower Training II (0.8 Injuries/1000TH) and higher Match II (8.4 Injuries/1000MH) in elite first division players. Ekstrand et al [53] described an higher Total II (2.48 Injuries/1000EH), a slightly higher Training II (1.37 Injuries/1000TH) and higher Match II (8.70 Injuries/1000MH) in professional elite footballers. They report that Muscle II is six times higher in matches than in training. [53] For Muscle injuries, our results are very similar to those of elite professional footballers. Again, similar results are seen between elite adult and our young footballers, as suggested by Chomiak et al [52].

MAI were divided between training (57.14%) and match (42.86%) injuries. Only two (5.71%) were due to contact with another player, while the remaining (94.29%) were non-contact injuries. Five (14.29%) Muscle injuries were recurrences and 85.71% were index injuries. Similarly, Ekstrand et al [53] calculated a 16% recurrence rate.

For TLI, four (57.14%) occurred in matches and three (42.86%) in training. All of TLI were non-contact injuries and index injuries. This is in accordance with Ekstrand et al [53], where more than 90% of injuries occurred in noncontact situations, but traumatic events were the cause of two thirds of Muscle injuries. FP occurred in 5% of cases and 60% of Hamstring Strains occurred in the dominant leg (preferred kicking leg). Hagglund et al [41] found that overuse injuries (34%) affected mainly the Adductors. Hamstring Strains occurred during matches (67%) and training (32%). [34]

Almost eighty-six per cent (MAI) to 100% (TLI) of Muscle injuries were index injuries, revealing a low recurrence rate. We believe that this occurred due to appropriate rehabilitation of injuries and realization of individual prevention / fitness plans.

Several authors refer that Muscle Strains don't seem correlated with exposure to matches and training. [74] Although train exposure is higher than match exposure, no clear differences were found between different turfs and sessions (train, match) when considering Muscle Strain injuries and Ankle injuries for male football players. [2, 3] Others show that teams playing in 3GAT reported less Muscle injuries (6.16 Injuries/1000MH) in matches than those on NG (8.75 to 9.58 Injuries/1000MH). [53] Our findings were 1.78 Injuries/1000MH and 5.33 Injuries/1000MH for 3GAT and NG, respectively.

Eighty per cent of MAI were Slight. The remaining MAI / TLI were evenly distributed through Minimal, Moderate, Severe (MAI: 5.71%; TLI: 28.57%), and Mild (MAI: 2.86%; TLI: 14.29%) severity.

For both MAI and TLI, Muscle injuries resulted in 117 days of absence from play. Every Muscle injury averaged 3.34 ± 10.19 (MAI) and 16.71 ± 18.11 (TLI) days of absence. This is similar to what evidence shows, that Muscle injury recurrences (16%) resulted in longer absence time than the index injury (17.8 ± 25.2 vs. 13.8 ± 17.0 days). [53] Fifty-eight per cent of cases resulted in more than 1 week of absence, and 11% caused more than 4 weeks of absence. This time-loss can affect team performance. [53, 64]

Almost two thirds (65.71%) of MAI occurred in the preseason. This difference is even higher for TLI, with 85.71% of preseason Muscle injuries. It has been described that injuries can be up to three times more prevalent in preseason training than regular season. [63] The main reason would be that, at preseason, players have not yet reached appropriate fitness levels that allow them to properly withstand the particularities of competitive football. Inappropriate training programs (e.g.: increased intensity) that don't allow adaptation (fatigue related) may be associated with IR in preseason. [5, 13, 19, 20, 48, 63] Other reasons have been raised for Muscle injuries, such as age, anthropometric characteristics, ethnicity, muscle tension and strength imbalances, biomechanical and movement control pattern dysfunctions, inadequate or inexistent prevention plans, and previous history. [34, 75, 149]

Regarding Muscle injuries, an increase by 40% in IR of the Quadriceps muscle was seen during preseason. The increased number of kicking actions during this time likely explains this finding, and eccentric exercise protocols should be implemented to prevent it. [41] More than 80% of Thigh Muscle injuries, common in youth football, are related with non-contact mechanisms of injury. Muscle conditioning protocols during preseason should be emphasized in order to alter this tendency. [53, 64]

Joint injuries

The third most prevalent type of injury was the Joint injury (MAI: 12.90%; TLI: 16.67%).

For MAI, almost two thirds of joint injuries were in the lower limbs (65.00%), specially the Ankle (50.00%) and the Hand / Finger / Thumb (25.00%). Every TLI occurred in the Ankle (100.00%).

For MAI, Total II was 5.75 Injuries/1000EH, Training II was 4.46 Injuries/1000TH and Match II was 12.44 Injuries/1000MH.

For TLI, Total II was 1.44 Injuries/1000EH, Training II was 0.34 Injuries/1000TH and Match II was 7.11 Injuries/1000MH. Arnason et al [49] found a similar Total II (1.3 Injuries/1000EH) and Training II (0.4 Injuries/1000TH), but a lower Match II (5.5 Injuries/1000MH).

For MAI, match injuries (35.00%) were almost half the training (65.00%) injuries. Four Joint injuries (20.00%) were non-contact. Injuries by contact with another player (45.00%), the ball (10.00%), or other object (25.00%) also occurred. Six injuries (30.00%) were recurrences, and the remaining 70.00% were index injuries.

For TLI, 60.00% were recurrences and 20.00% were due to non-contact. Eighty per cent were match injuries and Lateral Ankle Sprains. We calculated II for Lateral Ankle Sprains (MAI: 2.30 Injuries/1000EH; TLI: 1.15 Injuries/1000EH) and no Knee Sprains occurred. Evidence states that Lateral Ankle Sprains may have the highest rate (up to 1.50 Injuries/1000EH) and Knee Sprains are incident in male footballers (0.14 Injuries/1000EH). [8] Ankle Sprains may account for 67% of all Ankle injuries (73% involving the ATFL, 14% the Medial Ankle Ligaments, and 4% the Anterior and Posterior Tibiofibular Ligament and Interosseous Membrane). This is in accordance with the demands of football (e.g.: kicking, tackling, player-to-player contact, cutting manoeuvres, landing, twisting and turning, running). [33, 54, 55]

It is the Ankle Sprains' incidence that makes them a problematic injury in football, not so much their severity. [33] Although Lateral Ankle Sprains were not the most prevalent overall injury, it is verified that it still is an important slice of Joint injuries when in more demanding competitive situations. This shows that an important work has been done preventing such injuries, but that should remain a priority of intervention. To prevent Ankle Sprains, the implementation of proprioceptive and conditioning training (including preinjury measures of ankle stability) during the closed season and preseason should be done. [33, 156]

Three fourths (75.00%) of MAI were Slight. The remaining were of Minimal (MAI: 20.00%; TLI: 80.00%) or Moderate (MAI: 5.00%; TLI: 20.00%) severity.

For both injury definitions, Joint injuries caused 20 days of absence from play, ranging from none to 13 days. Every Joint injury caused 1.00 ± 2.92 (MAI) and 4.00 ± 5.05 (TLI) days of absence. Woods et al [33] describes absence from play as less than one month in 83% of cases, and suggests that both low severity of Ankle Sprains and short rehabilitation period that may lead to reinjury (9%).

Both injury definitions tended to show a higher number of injuries in the competitive season (MAI: 65.00%; TLI: 60.00%) than preseason (MAI: 35.00%; TLI: 40.00%). Evidence shows that injuries tend to be more prevalent in preseason [63], but that was not verified in our study, for Joint injuries. Woods et all [33] found that 44% of Ankle Sprains were sustained in the first 3 months of the season. We believe this could be due to higher aggressiveness in the competitive season, given that during closed season and preseason players were given individual plans for injury prevention. For this reason, the negative effects of the closed season (decreased activity) might have been attenuated for Joint injuries.

Pattern of moderate and severe injuries

Moderate injuries

Only one (16.67%) Moderate injury didn't occur in the lower limbs. The remaining (83.33%) affected the Thigh, Ankle and Knee joints.

While most of them were non-contact injuries (83.33%), half (50.00%) were traumatic. Only one third (33.33%) of Moderate injuries were recurrences.

Moderate injuries caused 108 days of absence from play. Every Moderate injury caused an average of 18.00 ± 6.51 days of absence. Our results are below those recorded by Walden et al in the Swedish elite football [40] (82.6 ± 79.4 days) and in a UEFA injury study [13] (81.9 ± 54.6 days).

A third of them were Muscle injuries (33.33%) causing most days of absence (31). Our findings are in accordance with most published evidence. [13, 20, 35, 38, 40, 96, 140, 149]

The competitive season showed twice (66.67%) the Moderate injuries than preseason (33.33%).

Severe injuries

The upper body was the most affected location (57.14%). The Head (42.86%) and the Thigh (28.57%) were the most prevalent locations for Severe injuries. Most injuries were Fractures (42.86%) and Muscle injuries (28.57%).

Training injuries (57.14%) were slightly more prevalent than match injuries (42.86%). An IR of 0.2 injuries per match was calculated. Most injuries resulted from contact with another player (57.14%), while the remaining were non-contact (42.86%). The same pattern occurred for traumatic (57.14%) and overuse (42.86%) injuries. Only one Severe injury was a recurrence (14.29%). Others found a twenty-four per cent recurrence rate for Severe injuries. [52]

The highest Severe II was found in the men's Under-21 and women's U-19 tournaments. IR was higher (0.9 injuries per match) than the reported by elite professional clubs. [47] Brito et al points the U-19's as the age group that sustained the highest incidence of Severe injuries. [1, 10]

Chomiak et al [52] found that Severe injuries account for 16.5% of all injuries. These were divided between lower extremity (74.2%) and upper extremity (14.4%). Knee (29%), Ankle (19%) and Spine (9%) were the most affected body locations. The most common diagnosis was Joint Sprain (30%), Fracture (16%), Muscle Strain (15%), Ligament Rupture (12%), Meniscal Tear and Contusion (8%). He also recorded slightly more match's severe injuries (59%) than us. Severe injuries were caused by trauma (81.5%) or overuse (18.5%), 31% were due to FP and 24% were recurrences.

Darrow et al [17] refer the Knee (38.9%), Ankle (16.0%), and Head / Face (11.2%) as the most affected locations. Fractures (30.3%), complete Ligament Sprains (20.3%) and incomplete

Ligament Sprains (13.6%) are also referred. Competition's Severe IR was higher than training's, and more common among girls. [17]

Severe injuries caused 488 days of absence from play, which corresponds to 69.71 ± 46.37 days of absence per injury, in average. Most absence days (266 days) were due to Fractures.

Ekstrand et al [53] refer that Severe Muscle injuries (11%) caused more than 4 weeks of absence. Quadriceps Strains were the type of injury that caused the longer absences (17 days). Fifty-eight per cent of severe Muscle injuries resulted in more than 1 week of absence. [53]

Most Severe injuries occurred during preseason (57.14%). Brito et al [10] describes a peak of severe injuries on preseason and after midseason break. This latter was not verified in our study.

Injury consequences in sports practice

The impact of an injury on a club can be considered in relation to its severity and the number of potential competitive matches missed. [19] Football Academies are institutions where young players try to develop their skills in order to become elite footballers. This skill acquisition is what's affected when injury causes absence (up to 6% of the season) from training and competitive sessions. In professional clubs, injury has a different impact, measured by the missed competitive matches and its' effect on the performance of the team or player's wages. [5]

Absence due to injury

Football shows higher risk of injury, IR and absence from play due to injury than other sports. [22] This causes interruption of practice and absence from play, affecting team performance, morale and results. In academy settings, development slows down. Injured players can be in rehabilitation up to several months or, in some situations, develop loss of function and chronic pain resulting in decreased or inexistent participation in sport. [5, 8, 17-20]

It has also been described that the majority of youth football injuries (70-80%) are Minor or Moderate, not resulting in significant (a maximum of 7 days) absence from play. [1, 15, 21]

In our study, throughout the season, a total of 820 absences (due to injury) from training / matches were recorded, averaging 43.16 ± 63.60 absences per player. A mean of 37.37 ± 54.96

training absences per player occurred, totalizing 710 absences (86.59%). For matches, 110 absences (13.41%) occurred (average of 5.79 ± 8.66 absences per player).

For MAI, 4.75 ± 19.40 days of absence per injury occurred. For TLI, 24.57 ± 38.67 days of absence per injury were recorded. This value is above most studies [13, 19, 38, 40, 48, 61, 140, 141, 153] we analysed (11.8 [38] to 24.2 [19]). Only Ekstrand et al [35] recorded a higher value (37).

Hawkins et al [19] describes lower values than ours, with each player losing a mean of 24.2 days (4.0 matches, in average) per injury. Cloke et al [64] studied young footballers (8-16 years) over 5 seasons and concluded that Muscle injuries are the main reason for training absence (in our study, Fractures caused the most absence from play, followed by Joint and Muscle injuries). Thigh Muscle injuries caused a median of 13 days of training absence. Ekstrand et al [53] shows that 58% of cases resulted in more than 1 week of absence. Severe injuries (11%) caused more than 4 weeks of absence and Quadriceps Strains were the type of injury that caused the longer absences (17 days). This time-loss can affect team performance.

As described before, recurrences (25.1 days) cause more time of absence than index injuries (19.1 days). [19] The same occurred for Muscle injuries (17.8 ± 25.2 vs. 13.8 ± 17.0 days). [53]

An average of 102.50 (88.75 and 13.75 absences / month for training and match, respectively) absences occurred, per month. September was the month with most absences (22.20%) and March with the least (4.27%). Training absence followed the same pattern. Match absences were higher in November (19.09%) and February (19.09%) and lowest in August (4.55%).

Team absence due to injury was also calculated for both training and matches. This refers to the mean percentage of players that are injured and therefore not available to participate in training and matches.

September (27.50%) was the month with the highest absence due to injury, and March (8.21%) the least. In average, 17.56% of the team did not participate in the sessions every month.

In average, team training (17.79%) and match (17.20%) absence due to injury showed similar results. Training team absence was highest in September (28.41%) and lowest in March (8.08%). October (26.39%) was the month where match absence due to injury showed the highest percentage, and March (8.84%) the least.

In order to decrease absence from play, prevention measures should be implemented but for that further investigation on RF and mechanisms of injury should be done. [53] Factors like player and staff awareness (e.g.: don’t play with Groin pain) would be important. [44]

Absence due to illness, trial participation or others

Main absence to training and matches occurred because of sustained injuries (80.23% of absences), but the remaining 19.77% absences were due to other reasons, such as trial participation (10.08%), illness (2.45%) and others (7.24%) (Family issues, exam realization, school participation, sports injuries not included in the injury definition, out of match selection).

Psychological factors such as major life events (e.g.: death of a close friend or family, separation from boyfriend / girlfriend) could increase risk of injury by up to 70%. [8, 87] Excessive pressure to perform well in sports, poor psychological coping skills and lack of social support has also been associated with injury. [86] This shows the importance of investigating in this area.

In average, per month, 102.50 absences occurred due to injury, 12.88 because of trials (highest in February (54), lowest in August and March (0)), 3.13 due to illnesses (highest in January (15), lowest in August and October (0)), and 9.25 for other reasons (highest in March (26), lowest in August and January (0)).

Team availability

Team availability throughout the season is related with mean player participation in training / matches, displayed as a percentage. The higher the percentage, the more players are available.

In average, 78.83% (13 to 14 players) of the team was available, per month. Lowest team availability occurred in September (70.14%) and the highest in August (87.99%). We believe this is a very good percentage of availability given that, not only almost 80% of the team is available, but also because we know that up to 20% of absences are caused by other reasons than injury.

Mean team availability was 79.16% and 80.04% for training and matches, respectively. Availability for training was highest in January (88.31%) and lowest in September (68.73%). For matches, August was the month with the highest percentage of team availability (86.11%), and October with the least (73.61%).

Team availability was understandably higher at the start of preseason, as players tend not to be injured after the closed season. At the start of our study, some players that got injured by the end of the previous season were still receiving treatment. Our team availability was high, given the small amount of players that the academy had.

Training sessions and matches lost due to injury

Injury consequences were also analysed individually, by the mean number of lost sessions (training and matches) throughout the season.

Every player lost, in average, 5.39 sessions (4.67 training sessions and 0.72 matches) per month, due to injury. This is about one sixth of all sessions given that an average month would contemplate 27.75 training sessions and 4.38 matches.

The month where most sessions were lost was September (9.58). The least was March (1.84). Lost training sessions followed the same pattern.

For matches, November and February showed the highest amount of lost sessions (1.11), while August showed the least (0.26).

This difference between months is not directly related with injury severity, but with the number of sessions that occurred during that given month. In our academy, training would generally occur twice a day and matches twice a week. Injury severity was measured in days of absence (not sessions lost). The months that counted most sessions were September and November, and least were December and March. Most matches occurred in November and February, and the least in August. This is in accordance with our findings.

Some authors refer that a congested calendar had no influence on risk of injury for elite professional footballers. [13, 91] Studies on professional elite footballers point that, understandably, too many matches in a short period of time can result in fatigue (inadequate recovery), low performance and increased risk of injury. Dupont et al analysed the effect of 1 vs. 2 matches per week on physical performance and IR in elite professional footballers. Recovery time between matches (72-96 hours) was enough to maintain physical performance levels, but not to maintain low IR, that with two matches per week was more than six times higher than with only one match. [4] More studies should be done trying to properly clarify why and to what extent proper recovery between matches is not entirely related with IR. UEFA Injury studies show that a busy match calendar may cause physical and mental fatigue to the players, not allowing important footballers to rest and recover properly prior to championships. They even emphasize the importance of these effects on young players' injuries. [47]

Fatigue, both central brain and local muscle, is suggested to play a role in this injury behaviour. Inadequate recovery opportunity during the halftime break is also suggested. A decrease in the eccentric hamstring strength over time was found and could support this theory. [5, 19, 34, 41, 45, 64, 89]

General fatigue due to stress, inadequate nutrition, poor sleeping patterns is also suggested as a cause for central nervous system fatigue. [34] Immaturity of both physiological and musculoskeletal systems and neuromuscular fatigue were also pointed as possible reasons. [5]

Injury Burden

Injury Burden relates to a measure of injury consequence for the player / team that considers injury frequency (incidence) and severity to calculate a score.

For this season, Total Injury Burden was 211.77 Days of Absence/1000EH. Injury Burden for matches (669.89 Days of Absence/1000EH) was more than five times higher than for training (123.40 Days of Absence/1000EH). Not only more match injuries occurred, but match injury severity was also higher than trainings'.

Other studies calculated Injury Burden scores for Hamstrings (13.2), Quadriceps (7.0), Adductors (8.0), and Calf (4.6) muscle injuries. [53]

These findings are in accordance with other studies, which report that athletes show 4-6 times higher IR in matches than in training. [1, 21, 63] UEFA European Championships recorded more injuries during matches. [47] II was found to be higher in youth football matches when compared with training. High match intensity of play and aggressiveness are pointed as probable reasons, linked with the immaturity of both physiological and musculoskeletal systems and neuromuscular fatigue. [5, 10, 15]

5.2. Strengths and limitations of the study

This study followed the recommendations of the consensus statement on injury definitions and data collection procedures specifically developed for football injuries, for this type of study and sample. [12] Moreover, quality evidence has been published to prove its methodological worth and that it allows the correct and uniform collection of data by the investigation teams, is replicable and comparable, thus increasing the quality of the study. This study's main strengths are pointed below.

- Prospective study design (reducing recall bias and errors in data recording that are linked with non-prospective studies);

- Exposure times (for training and matches) were not estimated, but rigorously, exhaustively and accurately recorded for each player individually (especially in matches), promoting an adequate Injury Incidence calculation;
- Data collection was performed by the Physiotherapist of the academy, helped by the academy physician and coaching staff (technical, exposure information and session duration). This allowed total control of the recorded information;
- Accuracy of the recording of injured cases was guaranteed by the academy's medical staff (physiotherapist and physician) leading to the recording of pertinent information and constant update (high reliability). Data analysis was done by the Physiotherapist / Investigator.

Both injury definitions show advantages and disadvantages. The most important is the inability for study comparison. In our study, both injury definitions (MAI and TLI) were used allowing comparison between with both types of studies but, more importantly, between injury definitions. Although inferential statistics was not possible to apply, interesting conclusions were obtained from the analysis of the same injuries using two different injury definition approaches.

The quality / reliability of the injury collection and exposure recording has been described has the basis for epidemiologic study quality. Concept definition and data collection methodology have been described as the main reasons for the inability to compare studies. [12, 36] Although standard definitions and UEFA forms were correctly used it was the first time that the Academy staff participated in this type of study, which means that methodological and technical improvement is still possible.

Information on **previous injuries** (or index injuries for recurrences) was only affected by the players' recall bias on injuries sustained before their start at the academy.

Another important limitation was the **study duration** (less than one season – eight months), although this was not related with the study itself. More than one season (study period) recording is recommended but evidence also shows that one season recording may be enough if other injury influencing factors are not present. [39] Our study fails to reach one season recording.

Sample size was also an important limitation in our study, as it limited the type of statistical analysis and, for that reason, the possibility of comparison with some studies (although it was not the main purpose of our study).

The **power of a study** may be affected by sample size (reduced in our case), effect size and accepted significance level. The power of a study is the ability to demonstrate an association between a RF and injury (given that an association exists) (external validity – generalization for the population of footballers), even if internal validity is guaranteed. Factors that affect the power of a study include the strength of the true association between RF and injury risk (stronger associations require fewer cases), injury frequency (the more frequent, the fewer cases needed) and the significance level (generally, $p<0.05$). The power would increase if a bigger sample was studied (we studied every footballer from the academy). For moderate to strong associations, 20 to 50 injury cases are needed. For small to moderate associations, 200 injured subjects are necessary. [9]

Although the main purpose of this study was not related with finding significant **Risk Factors**, we intended to point some possible clinical associations that would promote future studies. Injury occurrence is multifactorial, as factors are interrelated and affect each other. For this reason, every author should include as much clinically relevant, sensible, specific factors as possible, with strong associations. When trying to associate injury occurrence with a sole RF, conclusions will not be complete and should be taken carefully. This is why inferential statistics (multivariate approach) are important, which was not possible to use in our study because of our reduced sample. [9] We studied every athlete from the academy and this did not affect the study of injury pattern and characteristics, but it would be of great interest in order to analyse injury and RF associations.

Transformation of continuous **variables** into dichotomous variables can be also considered a study limitation, as information is lost and statistical possibilities decrease.

Another limitation was that we did not record **hour of injury**, mainly during matches. This prevented us from studying injury pattern during matches, a phenomenon described in the literature and usually explained by fatigue. [5, 47]

Our team participated in different types of matches (championship, friendly) with different teams (seniors, juniors), difficulties (high and very low competitiveness / difficulty) and results (win, draw, loss). This might have an effect on motivation, physical demand and potentially injury occurrence and pattern. Bengtsson et al [92] investigated the association between match characteristics (result, venue, type of competition) and injury occurrence. We did not record and analyse some of this information mainly because there is no objective described way of recording match difficulty that could be related with injury occurrence.

5.3. Recommendations for future studies

Every study should follow the recommendations of the consensus statement on injury definitions and data collection procedures developed for football injuries, in order to be fully adequate, replicable and comparable. [12] These methodological recommendations allow the complete understanding of this and future studies.

- All the players from the team should be included in the study sample. With a larger study sample, the power of the study would increase and inferential statistics application would be possible, leading to more and better conclusions;
- The study duration / follow-up should contemplate a minimum of one whole season;
- All the study variables should be fully recorded, as soon and as complete as possible, and registered by the investigator or by someone inside the study protocol. The investigator should be present in all the stages of the process, thus reducing errors and bias;
- Exposure times should be accurate and recorded individually for each player (not estimated);
- Absences from sessions should be properly recorded and reasons explained, whether it is an injury or other;
- Both injury definitions should be used while recording injuries (MAI include all TLI). This allows complete understanding of injury patterns and doesn't exclude complaints that with a TLI definition would be rejected. As they can affect player performance and health, future studies could even include pre-existing (chronic) injuries and other medical conditions (e.g.: illnesses, diseases) [16];
- A multivariate approach to RF should be done. Injuries are generally multifactorial, resulting from the interdependence and influence between RF;
- Some studies refer injury occurrence during match warm-up and extra-time (usually characterized by high intensity play). This could be considered in future studies and forms. This information could give us information on risk of injury and possibly severity.

This type of study should be introduced to every team comprised in top leagues, allowing the proper understanding of injury patterns using a replicable and comparable model (between teams, championships, countries). This way, prevention measures to reduce injury occurrence would be highly specific, cost-friendly and would result in less health-related cost by football teams. Ideally, every team would study this information and for bigger centres, different modalities would be included.

Different matches (in type and difficulty) may have a potential effect on injury occurrence and pattern. The creation of an objective way (variable) of measuring match difficulty (as perceived by the player, by the coach, or both) should be addressed by future studies, trying to find different injury patterns between teams that play at different levels. A match perceived as difficult is intended to result in more injuries just because of higher physical demand? A player will be more probably injured if playing in a match he believes easier?

6. CONCLUSIONS

Our results show that Association Football remains a sport with high risk of injury. Throughout the season, 18 out of 19 players sustained at least one injury. MAI prevalence during this season was 94.74% (8.16 injuries per player). TLI prevalence was 63.16% (1.58 injuries per player).

For MAI, Total II was 44.54 Injuries/1000EH. Match II was more than six times higher than training's. For TLI, Total II was 8.62 Injuries/1000EH. II was up to almost seven times higher in matches than training.

Up to three quarters of injuries occurred in the lower limbs. MAI were most seen in the Lower Leg / Achilles Tendon, followed by the Knee and Thigh. TLI mainly affected the Thigh and Ankle.

Both injury definitions showed a similar type of injury pattern, with Haematoma / Contusion being the most common (MAI: 44.50%; TLI: 26.67%), followed by Muscle (MAI: 22.60%; TLI: 23.33%) and Joint injuries (MAI: 12.90%; TLI: 16.67%).

Most Muscle injuries occurred in the lower limbs (MAI: 65.71%; TLI: 100.00%), namely the Thigh. For MAI, Total II was 10.06 Injuries/1000EH. For TLI, Total II was 2.01 Injuries/1000EH. Muscle injuries resulted in 117 days of absence from play, each averaging 3.34 (MAI) and 16.71 (TLI) days of absence.

Two thirds of Joint MAI were in the lower limbs, specially the Ankle and the Hand / Finger / Thumb. Every TLI occurred in the Ankle. For MAI, Total II was 5.75 Injuries/1000EH. For TLI, Total II was 1.44 Injuries/1000EH. Eighty per cent were Lateral Ankle Sprains (MAI: 2.30 Injuries/1000EH; TLI: 1.15 Injuries/1000EH). Joint injuries caused 20 days of absence from play, each causing 1.00 (MAI) and 4.00 (TLI) days of absence.

Both Ankle Sprains and Hamstring Strains showed low prevalence when compared with other studies. More than two thirds of injuries were traumatic while the remaining were overuse injuries. Around twenty per cent of these injuries were due to opponent FP.

Most Moderate injuries (83.33%) affected the Thigh, Ankle and Knee joints. Severe injuries occurred mainly in the upper body (57.14%). The Head and the Thigh were the most prevalent locations. Most injuries were Fractures and Muscle injuries. An IR of 0.2 injuries per match was calculated.

Rate of recurrence was 10.97% and 23.33% for MAI and TLI, respectively.

Almost sixty per cent MAI occurred in NG, followed by 3GAT (36.77%). TLI followed the same pattern. All the other surfaces used in training showed almost no injury occurrences.

In average, 78.83% (13 to 14 players) of the team was available, per month. Mean team availability was 79.16% and 80.04% for training and matches, respectively. Our team availability was high, given the small amount of players that the academy had.

Total Injury Burden was 211.77 Days of Absence/1000EH. Injury Burden for matches was more than five times higher than for training. Not only more match injuries occurred, but match injury severity was also higher than trainings'.

Association Football is a world recognized team sport and is highlighted as a safe activity with few harmful consequences for a large spectrum of the population. It plays an important role on the development of young players, and football-related injuries (and consequent absence from play, missed development, and economic burden) may occur.

High exposure to the physical and mental demands of football may predispose players to injury. Understanding the differences between young athletes and mature adult athletes, as well as behavioural and environmental risks, will help clinicians guide the prevention, diagnosis and management of sports injuries in children and adolescents.

For this, methodologically strong epidemiological studies should help coaching and medical staffs from football clubs and academies to adhere to health and safety legislation, and provide valuable information allowing them to create effective and efficient prevention and fair-play strategies. These will be adapted to reality by understanding injury characteristics (e.g.: prevalence, incidence, pattern, RF).

This type of studies is scarce for young footballers, and that is where this study intends to give a contribution.

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8. APPENDIXES / ATTACHMENTS

8.1. ATTACHMENT 1 – Consensus Statement on Injury Definitions and Data Collection Procedures in Studies of Football (Soccer) Injuries

REVIEW

Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries

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Variations in definitions and methodologies have created differences in the results and conclusions obtained from studies of football (soccer) injuries, making interstudy comparisons difficult. Therefore an Injury Consensus Group was established under the auspices of Fédération Internationale de Football Association Medical Assessment and Research Centre. A nominal group consensus model approach was used. A working document on definitions, methodology, and implementation was discussed by the group. Iterative draft statements were prepared and circulated to members of the group for comment before the final consensus statement was produced. Definitions of injury, recurrent injury, severity, and training and match exposures in football together with criteria for classifying injuries in terms of location, type, diagnosis, and causation are proposed. Proforma for recording players' baseline information, injuries, and training and match exposures are presented. Recommendations are made on how the incidence of match and training injuries should be reported and a checklist of issues and information that should be included in published reports of studies of football injuries is presented.

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It has been well documented that variations in definitions and methodologies create significant differences in the results and conclusions obtained from studies of sports injuries.[1–11] Medical journals have developed strategies, such as the CONSORT statement[12] for randomised controlled trials, to address these problems and to improve the quality of published studies. However, despite continuing calls for common methodologies to be adopted, fundamental differences in definitions and implementation strategies have persisted in published studies of football injuries. This consensus statement aims to establish definitions and methodology, implementation, and reporting standards that should be adopted for studies of injuries in football and to provide the basis for studies of injuries in other team sports.

METHOD

After informal discussions during the 1st World Congress on Sports Injury Prevention in Oslo in June 2005, the Fédération Internationale de Football Association Medical Assessment and Research Centre (F-MARC) agreed to host an Injury Consensus Group comprising a range of experts involved in the study of football injuries. A nominal group consensus model approach[13] was adopted for producing a consensus statement on definitions and methodological issues related to studies of football injuries. A working document identifying key issues associated with data collection and reporting in surveillance, risk factor, and intervention studies was produced to structure discussions at a two day meeting in Zurich. After this meeting, iterative draft consensus statements were prepared and circulated to members of the group for comment before this final statement was produced.

DEFINITIONS

Injury

An injury is defined as:

> Any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities. An injury that results in a player receiving medical attention is referred to as a ''medical attention'' injury, and an injury that results in a player being unable to take a full part in future football training or match play as a ''time loss'' injury.

''Medical attention'' refers to an assessment of a player's medical condition by a qualified medical practitioner. ''A player being unable to take a full part in future football training or match play'' is independent of whether a training session actually takes place on the day after the injury or whether a player is selected to play in the next match. The term ''future'' refers to any time after the onset of injury, including the day of injury. It is important to recognise that variations in medical support and practice and in an individual player's tolerance to pain may create differences in the incidence of injury reported in studies. Multiple injuries sustained by a player in a single event should be recorded as one injury with multiple diagnoses. Injuries that are unrelated to football competition or training should not be recorded in studies of football injuries. Players may also experience problems other than physical complaints, such as illnesses, diseases, and mental complaints, and it may be appropriate in specific studies to record these problems; however, their incidence should be reported separately from the incidence of physical complaints.

Recurrent injury
A recurrent injury is defined as:

> An injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury. A recurrent injury occurring within two months of a player's return to full participation is referred to as an ''early recurrence'', one occurring 2–12 months after a player's return to full participation as a ''late recurrence'', and one occurring more than 12 months after a player's return to full participation as a ''delayed recurrence''.

It is essential to adopt the same recording regimen for recurrent injuries as that adopted for index injuries—that is, ''all'', ''medical attention'', or ''time loss'' injuries—because the recording regimen affects the reported incidences of both index and recurrent injuries. When recurrent injuries are recorded, the site of the injury, such as the specific muscle or ligament, rather than the general location of the injury, such as the thigh or knee, should be considered. Index injuries sustained before the start of a study should also be considered when identifying an injury as a recurrence. Injuries such as contusions, lacerations, and concussions and sequelae resulting from an index injury should not be recorded as recurrences. Recall bias[6] is less likely to affect the recording of early recurrent injuries than it is for late and delayed recurrent injuries because of the shorter time period between the two injuries.

Injury severity
Injury severity is defined as:

> The number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection.

The day on which an injury occurs is day zero and is not counted when determining the severity of an injury. Therefore, if a player cannot participate fully on the day of an injury but is available for full participation the next day, the incident should be recorded as a time loss injury with a severity of zero days. If an injured player leaves a study or a study finishes before a player's injury has resolved, the attending clinician should estimate the total number of days that would have elapsed before the player returned to full participation if the player had remained in the study or the study had continued. If a player retires from play as a direct consequence of an injury sustained during a study before returning to full participation, the injury should be reported separately as a ''career ending injury''. Occasionally, an injury may have multiple diagnoses; in these cases, it is important to distinguish between the overall severity of the injury event and the severities of the individual diagnoses. The purpose of some studies may dictate that injury outcome measures other than days of absence, such as individual or team performances, costs associated with rehabilitation, insured and uninsured costs, or the long term impact on a player's quality of life, should be recorded.

Match exposure
Match exposure is defined as:

> Play between teams from different clubs.

Match exposure between teams from the same club should be regarded as training exposure. Any match activity that forms a part of a player's rehabilitation from injury should not be recorded as match exposure.

Training exposure
Training exposure is defined as:

> Team based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' football skills or physical condition.

Pre-match warm up and post-match cool down sessions should be recorded as training exposure. Motivational team talks, classroom discussions about tactics, and sessions with sports psychologists, nutritionists, etc should not be recorded as training exposure. Personal training activities undertaken by players away from their team and which are not planned by the team's coaching or fitness staff should not be recorded as training exposure. Any training activity forming a part of a player's rehabilitation from injury should not be recorded as training exposure.

Methodological issues
Studies should be of a prospective, cohort design to minimise the occurrence of errors associated with recall, which is a problem with retrospective study designs. Cohort studies that record players' exposures enable relations between the incidence of injury and risk factors in the study population to be explored.

Interpretation of injury definition
Most studies will record medical attention and/or time loss injuries. Table 1 presents examples of how specific incidents should be recorded under these recording regimens.

Injury classification
Injuries should be classified by location, type, body side, and mechanism of injury (traumatic or overuse) and whether the injury was a recurrence. In this context, a traumatic injury refers to an injury resulting from a specific, identifiable event, and an overuse injury to one caused by repeated micro-trauma without a single, identifiable event responsible for the injury. In some studies, diagnoses of injuries may be required; in these cases, a qualified medical practitioner should provide a specific written diagnosis or use a sport specific injury coding system, such as the Orchard[14] system.

Location of injury
The location of injuries should be recorded using the categories listed in table 2. The location of injuries should be recorded using the individual categories indicated but where the number of injuries in a study is small, it may be necessary to combine individual location categories into the main groupings for analysis purposes.

Type of injury
The type of injury should be recorded using the categories listed in table 3. The type of injuries should be recorded using the individual categories indicated, but where the number of injuries in a study is small, it may be necessary to combine individual type categories into the main groupings for analysis purposes. If the purpose of a study is to investigate other problems, such as illnesses, diseases, or mental complaints, these should be recorded under separate headings from those listed in table 3.

Other injury classification issues
Injuries should also be classified as to whether they occurred during a match or training session and whether they were the result of contact with another player or other object. It may also be appropriate to record whether the action causing the injury was a violation of the laws of football.

Table 1 Examples of how to record injuries under different recording regimens

Example	Injury recording regimen: Medical attention	Injury recording regimen: Time loss
1. A defender sustained a hamstring injury during a match that required 30 days of rehabilitation before he could return to full training. The player sustained another hamstring injury to the same muscle (same leg) 3 weeks later and required a further 50 days of rehabilitation before he could return to full training.	First incident should be recorded as an injury (severity: 30 days); second incident as a recurrence (severity: 50 days).	First incident should be recorded as an injury (severity: 30 days); second incident as a recurrence (severity: 50 days).
2. A goalkeeper developed shoulder instability and sought medical attention; the condition did not prevent him from taking a full part in team training or competition even though it caused him some pain. The team physiotherapist recommended an individual training programme for the goalkeeper to avoid aggravating the condition.	Episode should be recorded as an injury (severity: 0 days).	Episode should not be recorded as long as he remained able to take a full part in team training.
3. A defender sustained a groin injury, which the team doctor decided did not warrant immediate treatment; the player continued to take a full part in team training and competition. The player underwent elective surgery 2 months later and required 90 days rehabilitation.	Incident should be recorded as an injury (severity: 0 days); when the player underwent elective surgery, the severity should be reclassified to 90 days.	Incident should be recorded as an injury at the time of the player's elective surgery (severity: 90 days).
4. A defender suffered groin pain that did not result in time loss; this incident was followed by a 1 month pain-free period; he then suffered a further period of groin pain, which prevented him from training and which required 21 days of rehabilitation.	First episode should be recorded as an injury (severity: 0 days); second episode should be recorded as a recurrence (severity: 21 days).	First episode should not be recorded; second episode should be recorded as an injury (severity: 21 days).
5. A forward sustained an ankle sprain during a match but continued to play; he received medical attention after the match. He completed full team training using ankle taping (with some pain) for 6 days but aggravated the injury during the next match; he then required 15 days of rehabilitation.	First incident should be recorded as an injury (severity: 0 days) and when the second incident occurred the severity of the index injury should be reclassified to 15 days.	First incident should not be recorded and the second incident should be recorded as an injury (15 days).
6. A midfield player sustained a laceration to the face during a morning training session; the doctor sutured the cut but the player missed the afternoon training session. The player was able to take a full part in training on the following day.	Incident should be recorded as an injury (severity: 0 days).	Incident should be recorded as an injury (severity: 0 days).

Study population

The study population should normally consist of more than one team of players and the study should last for a minimum period of one season (including preseason), 12 months, or the duration of a tournament. Players joining/leaving the cohort—for example, through transfer into/out of a team—should be included/excluded from the date of joining/leaving. Injuries and exposures should be documented for every player within the cohort throughout the study period. Players who have an existing injury at the start of a study should not be excluded from the study, but their existing injuries should not be included as part of the study. For intervention and risk factor studies and for studies where the objective is to compare injury rates between groups, power calculations should be used to determine the population size required to identify significant differences in the effects being investigated.[15]

Implementation issues

Standardised data collection forms, which can be in electronic or paper format, should be used consistently throughout a study. Table 4 presents an overview of the forms that are normally required for a study of injuries in football.

Player's baseline information form

The exact nature of the baseline information required will depend on the purpose of the study; however, for surveillance studies, basic information, such as the player's age, sex, playing

Table 2 Main groupings and categories for classifying injury location

Main grouping	Category	Equivalent OSICS body area character
Head and neck	Head/face	H
	Neck/cervical spine	N
Upper limbs	Shoulder/clavicula	S
	Upper arm	U
	Elbow	E
	Forearm	R
	Wrist	W
	Hand/finger/thumb	P
Trunk	Sternum/ribs/upper back	C, D
	Abdomen	O
	Lower back/pelvis/sacrum	B, L
Lower limbs	Hip/groin	G
	Thigh	T
	Knee	K
	Lower leg/Achilles tendon	Q, A
	Ankle	A
	Foot/toe	F

OSICS, Orchard sports injury classification system.[14]

Table 3 Main groupings and categories for classifying type of injury

Main grouping	Category	Equivalent OSICS pathology character
Fractures and bone stress	Fracture	F
	Other bone injuries	G, Q, S
Joint (non-bone) and ligament	Dislocation/subluxation	D, U
	Sprain/ligament injury	J, L
	Lesion of meniscus or cartilage	C
Muscle and tendon	Muscle rupture/tear/strain/cramps	M, Y
	Tendon injury/rupture/tendinosis/bursitis	T, R
Contusions	Haematoma/contusion/bruise	H
Laceration and skin lesion	Abrasion	K
	Laceration	K
Central/peripheral nervous system	Concussion (with or without loss of consciousness)	N
	Nerve injury	N
Other	Dental injuries	G
	Other injuries	

OSICS, Orchard sports injury classification system.[14]

Table 4 Standard forms required for a study of injuries in football

Form	Information required	Who should provide the information?	When should the information be provided?
Player's baseline information	Player's characteristics	Each player	When a player enters the study
Injury report	Classification and circumstances of injury	Medical professionals	After each recordable injury
Match and training exposure	Player's match and training exposure time	Coaches	Every match and training session

position, stature, and body mass should be recorded, as these parameters define the study population. For other studies, such as interventions and investigations of relations between risk factors and the incidence of injury, more detailed baseline information may be required. Appendix A provides an example of a form for collecting a player's baseline information.

Injury form

The injury form should include the team's and player's study reference numbers, date of injury, whether the injury was sustained during a match or training exposure, description of the circumstances surrounding the injury, and the date of the player's return to full participation. The nature of the injury (location, type, side injured, recurrence) and the main mechanism (traumatic or overuse) should also be recorded. One free text section should be provided to enable a specific injury diagnosis or an injury classification code to be recorded. A second free text section may be required for some studies if additional study specific information is required. Injury report forms should be completed as soon as possible after the injury was sustained to avoid inaccuracies associated with recording information retrospectively. However, injury information should be revised/updated if further information is obtained at a later date—for example, from diagnostic tests. Appendix B provides an example of a form for recording injury information.

Match and training exposure form

The form should record the date, type, and duration (minutes) of each exposure. Exposures can either be collected on an individual player basis or for a group of players. Collecting individual player exposures, especially for training sessions, is very time consuming, and this level of detail should only be recorded if the information is specifically required to meet the aims of the study. However, for studies where players are exposed in a range of situations, such as club and country, or where the intention is to investigate relations between the incidence of injuries and individual risk factors, the actual exposure times for each player must be recorded. If data are collected on a group basis, the number of matches and training sessions, duration of each training session, and number of players attending each training session must be recorded. Training exposure data should preferably be collected for each training session, but, as a minimum, the information should be collected on a weekly basis. It may also be appropriate, depending on the purpose of the study, to record other variables, such as the playing surface or type of training undertaken.

For studies recording team match exposure, the total player-match exposure time in hours for a team is given by $(N_M P_M D_M)/60$ where N_M is the number of team matches played, P_M is the number of players in the team (normally 11), and D_M is the duration of the match in minutes (normally 90). Collecting match exposure data on a team basis rather than for individual players does not take into account exposure time lost because players are temporarily or permanently absent during a match through, for example, treatment or receipt of a red card. For studies recording team training exposure, the total training exposure time in hours is given by the sum of the values for $(P_T D_T)/60$ for every training session throughout the study, where P_T is the number of players attending a training session and D_T is the duration of the training session in minutes. Collecting team based training data rather than individual data does not take into account training exposure time lost when a player does not complete a full training session. Appendix C provides an example of a form for collecting match and training exposures for individual players, and appendix D provides an example for collecting team training and match exposures.

Other implementation issues

The purpose and setting of individual studies determine whether all, medical attention, or time loss injuries are recorded. Whichever injury recording regimen is adopted, it is essential that it is used consistently for all aspects of the study. Although collecting information on injuries without time loss may be important for investigating wider health issues, it must be recognised that this injury recording regimen places higher time demands on the medical personnel involved with the study. Although the exact format of the documentation required will depend on the specific aims and objectives of a study, the forms presented in appendices A–D provide a format for collecting the minimum amount of information that would normally be required. When new procedures are implemented, they should always be subjected to a pilot study before the main investigation is started.

The format and content of each study should be approved by and follow the protocols defined by an appropriate institutional ethics committee. Players should be assigned individual reference codes that are known only to the personnel recording information in order to maintain players' confidentiality when the data are analysed. Players taking part in a study should have the purpose and format of the study explained to them using face to face presentations or a detailed information sheet. Individual players must always retain the right not to take part and to withdraw from a study at any time. To maximise the level of compliance, a number of supporting initiatives can be implemented, such as providing written instructions for all personnel completing the forms and providing examples of completed forms. It is beneficial to identify a recognised contact person at each team, who does not have to be the person completing the forms. Regular contact should be maintained with each team, and feedback should be provided at appropriate points in time throughout the study.

REPORTING DATA

The cohort should be clearly defined by reporting the numbers of participants and teams taking part at the beginning of the study, the numbers of participants and teams dropping out and joining during the study, together with the age range and sex of the participants, the standard of play, and the duration of the study. Numbers of injuries occurring during matches and training should be reported separately, together with the corresponding match and training exposures so that the incidences of both match and training injuries can be calculated. The incidence of injuries should normally be reported as the number of injuries per 1000 player-hours; in studies reporting the incidence of match injuries, it may also be appropriate to report the number of injuries per match. Where possible, the incidences of all, medical attention, and time loss injuries should be reported separately, as this enables interstudy comparisons of results. The incidence of injury expressed as a function of total exposure time (match plus training) should only be reported if the incidences of match and training injuries are also reported separately. The incidence of injury should not be reported as a function of athlete exposures because the duration of individual exposures will vary. If the aim of a study is to measure the incidence of injury associated with specific training activities, then the incidence of training injuries should be reported as a function of the players' exposure to the specific training activities, such as the number of injuries during weight training per 1000 player-hours of weight training.

The average and median severity of injuries should be reported in days together with the distribution of injuries grouped according to their severity: slight (0 days); minimal (1–3 days); mild (4–7 days); moderate (8–28 days); severe (>28 days); career ending. The severity of injuries reported will be influenced by the recording regimen adopted in a study. The locations and types of injuries should be reported as numbers and percentages for both match and training

Table 5 Checklist of issues that should be included in reports of studies of football injuries

Section	Issues	Reported on page
Title	Identify the type and purpose of the study, for example, injury surveillance to measure or intervention to reduce the incidence of injuries.	
Abstract	Present a structured summary of the study, including Aims, Methods, Results, Discussion, and Conclusions.	
Introduction	Discuss background to and aims, objectives, and hypotheses for the study.	
Methods	Design of study, for example, prospective cohort, randomised controlled trial. Study population, including the organisational setting and geographic location, the numbers of players and teams involved, age range and sex of participants, level of play, and the duration of the study. Describe medical personnel involved and the frequency of recording injury and exposure data. Definitions of injury and exposure used in study. Planned interventions and the criteria used for selecting the intervention and control groups. Primary and secondary outcome measures, such as the number of medical attention/time loss injuries, cost of treatment, and the incidence and severity of injuries and recurrences. Methods used to define the study size in risk factor and intervention studies, for example, power calculations. Methods, such as training, used to improve the quality of data collection. Statistical methods used to compare groups and subgroups.	
Results	Report for the study population and each subgroup assessed: numbers of match and training injuries, numbers of match and training recurrences, match and training exposures. Present with appropriate statistical information for the study population and each subgroup: baseline data on the study population, incidences of match and training injuries, incidence of recurrences, severities of match and training injuries, distributions of injury locations and types for match and training, cross tabulations of injury locations and types for match and training. Present, together with inferential statistics, other summary data that are appropriate to the aims and objectives of the study.	
Discussion	Interpretation of study results, taking into account the study aims, objectives, and hypotheses and the existing evidence in the literature. Comment on generalisations that can be reached from the study results.	

injuries. It is also beneficial to cross tabulate the injury locations (table 3) with the types of injury (table 4), as this provides an understanding of the overall nature of the injuries recorded in a study.

If the times of match injuries are recorded, the injuries should be grouped into defined periods of the game (0–15, 16–30, 31–45 (+injury time), 46–60, 61–75, 76–90 (+injury time) minutes) and reported as percentages of injuries occurring in each of these periods; injuries sustained during extra time should be reported in a separate ''extra time'' period. Other results reported will depend on the specific purpose of the study but may include, for example, comparisons of the incidence and severity of injuries within subgroups of the study population, such as age, sex, skill level, or training programme. In each case, the data should be presented to an equivalent standard to the examples described above.

Finally, table 5 provides a checklist of issues that should be included in reports of studies on football injuries. The checklist is intended to describe the minimum information that should be included in a report; the aims and objectives of specific studies will dictate whether other information should also be presented. In principle, reports of studies should include sufficient information for readers to understand how a study was performed, to judge the quality of the information collected, and to assess the reliability of the findings presented.

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APPENDIX A

FIFA F-MARC For the Good of the Game

Players' Baseline Information Form

Team-code No: ____________

Logo

Player's code No.[1]	Playing position[2]	Age[3], years	Stature, cm	Body mass, kg	Dominant leg[4] (L/R/B)	Details of previous major injuries	Study specific variable	Study specific variable

Notes: [1] Use additional sheets if required [2] Goalkeeper, Defender, Midfielder, Forward [3] Age as at the start of season / year / tournament [4] Left, Right, Bilateral

APPENDIX B

FIFA F-MARC For the Good of the Game

Injury Report Form

(Team) Player-code: ____________ Date: ________

LOGO

1A Date of injury: ________ **1B Date of return to full participation:** ________

2A Injured body part

- ☐ head / face
- ☐ neck / cervical spine
- ☐ sternum / ribs / upper back
- ☐ abdomen
- ☐ low back / sacrum / pelvis
- ☐ shoulder / clavicula
- ☐ upper arm
- ☐ elbow
- ☐ forearm
- ☐ wrist
- ☐ hand / finger / thumb
- ☐ hip / groin
- ☐ thigh
- ☐ knee
- ☐ lower leg / Achilles tendon
- ☐ ankle
- ☐ foot / toe

2B Injured body part

☐ right ☐ left ☐ not applicable

3 Type of injury

- ☐ concussion with or without loss of consciousness
- ☐ fracture
- ☐ other bone injury
- ☐ dislocation / subluxation
- ☐ sprain / ligament injury
- ☐ lesion of meniscus or cartilage
- ☐ muscle rupture / strain / tear / cramps
- ☐ tendon injury / rupture / tendinosis / bursitis
- ☐ haematoma / contusion / bruise
- ☐ abrasion
- ☐ laceration
- ☐ nerve injury
- ☐ dental injury

☐ other injury (please specify): ____________

4 Diagnosis (text or Orchard code): ____________

5 Has the player had a **previous injury** of the same type at the same site (i.e. this injury is a recurrence)?

☐ no ☐ yes

If **YES**, specify date of player's return to full participation from the previous injury: ________

6 Was the injury caused by **overuse** or **trauma**?

☐ overuse ☐ trauma

7 When did the injury occur?

☐ training ☐ match

8 Was the injury caused by **contact** or **collision?**

- ☐ no
- ☐ yes, with another player
- ☐ yes, with the ball
- ☐ yes, with other object (specify) ________

9 Did the referee indicate that the action leading to the injury was a **violation of the Laws?**

☐ no ☐ yes, free kick / penalty ☐ yes, yellow card ☐ yes, red card

If **YES**, was the referee's sanction against: ☐ injured player ☐ opponent

APPENDIX C

FIFA F-MARC
For the Good of the Game

Exposure Report Form
(for the documentation of individual players' exposures)
(Team) Player-code: ____________________

LOGO

Date										
Training / Match										
Study specific variable										
Study specific variable										
Player Code No.	Report the duration of training and match play for each player (minutes)									

APPENDIX D

FIFA F-MARC
For the Good of the Game

Exposure Report Form
(for the documentation of team exposures)

(Team) Player-code: ____________________

LOGO

Date	Match / Training	No. of players (fully participa-ting in training)	Duration of training session (minutes)	Study specific variable	Study specific variable

8.2. ATTACHMENT 2 – Player's Baseline Information Form

FIFA F-MARC

For the Good of the Game

Players' Baseline Information Form

Team-code No: ____________

Logo

Player's code No.[1]	Playing position[2]	Age[3], years	Stature, cm	Body mass, kg	Dominant leg[4] (L/R/B)	Details of previous major injuries	Study specific variable	Study specific variable

Notes: [1] Use additional sheets if required [2] Goalkeeper, Defender, Midfielder, Forward [3] Age as at the start of season / year / tournament [4] Left, Right, Bilateral

8.3. ATTACHMENT 3 – Match and Training Exposure Form

APPENDIX C

Exposure Report Form
(for the documentation of individual players' exposures)
(Team) Player-code: ______________________

LOGO

Date										
Training / Match										
Study specific variable										
Study specific variable										
Player Code No.	Report the duration of training and match play for each player (minutes)									

APPENDIX D

FIFA F-MARC
For the Good of the Game

Exposure Report Form
(for the documentation of team exposures)

(Team) Player-code: ______________

LOGO

Date	**Match / Training**	**No. of players** (fully participa-ting in training)	**Duration of training session** (minutes)	**Study specific variable**	**Study specific variable**

8.4. ATTACHMENT 4 – Injury Report Form

APPENDIX B

FIFA F-MARC — For the Good of the Game

Injury Report Form

(Team) Player-code: ____________ Date: ________

LOGO

1A Date of injury: ________ **1B Date of return to full participation:** ________

2A Injured body part

☐ head / face	☐ shoulder / clavicula	☐ hip / groin
☐ neck / cervical spine	☐ upper arm	☐ thigh
☐ sternum / ribs / upper back	☐ elbow	☐ knee
☐ abdomen	☐ forearm	☐ lower leg / Achilles tendon
☐ low back / sacrum / pelvis	☐ wrist	☐ ankle
	☐ hand / finger / thumb	☐ foot / toe

2B Injured body part

☐ right ☐ left ☐ not applicable

3 Type of injury

☐ concussion with or without loss of consciousness	☐ lesion of meniscus or cartilage	☐ haematoma / contusion / bruise
☐ fracture	☐ muscle rupture / strain / tear / cramps	☐ abrasion
☐ other bone injury	☐ tendon injury / rupture / tendinosis / bursitis	☐ laceration
☐ dislocation / subluxation		☐ nerve injury
☐ sprain / ligament injury		☐ dental injury

☐ other injury (please specify): ________

4 Diagnosis (text or Orchard code): ________

5 Has the player had a **previous injury** of the same type at the same site (i.e. this injury is a recurrence)?

☐ no ☐ yes

If **YES**, specify date of player's return to full participation from the previous injury: ________

6 Was the injury caused by **overuse** or **trauma**?

☐ overuse ☐ trauma

7 **When** did the injury occur?

☐ training ☐ match

8 Was the injury caused by **contact** or **collision?**

☐ no

☐ yes, with another player

☐ yes, with the ball

☐ yes, with other object (specify) ________

9 Did the referee indicate that the action leading to the injury was a **violation of the Laws?**

☐ no ☐ yes, free kick / penalty ☐ yes, yellow card ☐ yes, red card

If **YES**, was the referee's sanction against: ☐ injured player ☐ opponent

8.5. APPENDIX 1 – Outputs SPSS®

The following tables were built using SPSS® and copied from the resulting output file.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	19	16,00	18,00	17,05	,52
Stature (cm)	19	170,00	189,00	179,21	5,19
Body Mass (Kg)	19	56,10	84,40	71,60	7,90
Body Mass Index (BMI) (Kg/m2)	19	18,96	25,02	22,25	1,82
Valid N (listwise)	19				

Playing Position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	9,52	9,52	9,52
	Goalkeeper	2	9,52	9,52	19,05
	Defender	5	23,81	23,81	42,86
	Midfielder	6	28,57	28,57	71,43
	Attacker	6	28,57	28,57	100,00
	Total	21	100,00	100,00	

Leg Dominance (B/R/L)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	9,52	9,52	9,52
	Bilateral	1	4,76	4,76	14,29
	Right	16	76,19	76,19	90,48
	Left	2	9,52	9,52	100,00
	Total	21	100,00	100,00	

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Total Exposure Time (min)	19	12880	2275	15155	208813	10990,16	4100,13
Total Match Exposure Time (min)	19	2620	305	2925	33767	1777,21	882,95
Total Training Exposure Time (min)	19	11244	1952	13196	175046	9212,95	3318,13
Total Missed Sessions	19	213	3	216	1022	53,79	59,33
Total Missed Training Sessions	19	184	3	187	895	47,11	51,14
Total Missed Matches	19	29	0	29	127	6,68	8,44
Total Missed Sessions (Injury)	19	215	0	215	820	43,16	63,60
Missed Training (Injury)	19	186	0	186	710	37,37	54,96
Missed Matches (Injury)	19	29	0	29	110	5,79	8,66
Total Missed Sessions (Trial)	19	29	0	29	103	5,42	9,01
Missed Training (Trial)	19	28	0	28	99	5,21	8,76
Missed Matches (Trial)	19	1	0	1	4	,21	,42
Total Missed Sessions (Illness)	19	11	0	11	25	1,32	2,89
Missed Training (Illness)	19	5	0	5	18	,95	1,81
Missed Matches (Illness)	19	6	0	6	7	,37	1,38
Total Missed Sessions (Others)	19	31	0	31	74	3,89	7,05
Missed Training (Others)	19	26	0	26	68	3,58	5,96
Missed Matches (Others)	19	5	0	5	6	,32	1,16
Valid N (listwise)	19						

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Injury Severity (Days of Absence)	155	166	0	166	737	4,75	19,40
Injury Severity (Missed Sessions)	155	181	0	181	755	4,87	20,67
Time since Previous Injury (days)	8	125	11	136	331	41,38	44,98
Valid N (listwise)	8						

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Injury Severity (Days of Absence)	30	165	1	166	737	24,57	38,67
Injury Severity (Missed Sessions)	30	180	1	181	754	25,13	41,73
Time since Previous Injury (days)	3	19	11	30	60	20,00	9,54
Valid N (listwise)	3						

Statistics

		Injury Severity (Days of Absence)	Injury Severity (Missed Sessions)	Time since Previous Injury (days)
N	Valid	155	155	8
	Missing	0	0	147
Mean		4,75	4,87	41,38
Median		,00	,00	21,00
Std. Deviation		19,40	20,67	44,98
Range		166	181	125
Minimum		0	0	11
Maximum		166	181	136
Sum		737	755	331

Injured Body Part

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Head / Face	3	1,94	1,94	1,94
	Wrist	2	1,29	1,29	3,23
	Hand / Finger / Thumb	5	3,23	3,23	6,45
	Hip / Groin	6	3,87	3,87	10,32
	Thigh	23	14,84	14,84	25,16
	Knee	28	18,06	18,06	43,23
	Lower Leg / Achilles Tendon	30	19,35	19,35	62,58
	Ankle	17	10,97	10,97	73,55
	Foot / Toe	11	7,10	7,10	80,65
	Neck / Cervical Spine	4	2,58	2,58	83,23
	Sternum / Ribs / Upper Back	3	1,94	1,94	85,16
	Abdomen	2	1,29	1,29	86,45
	Low Back / Sacrum / Pelvis	16	10,32	10,32	96,77
	Shoulder / Clavicula	5	3,23	3,23	100,00
	Total	155	100,00	100,00	

Injured Body Side

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not applicable	16	10,32	10,32	10,32
	Right	62	40,00	40,00	50,32
	Left	67	43,23	43,23	93,55
	Bilateral	10	6,45	6,45	100,00
	Total	155	100,00	100,00	

Injury Severity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Career ending	1	0,65	0,65	0,65
	Mild	2	1,29	1,29	1,94
	Minimal	14	9,03	9,03	10,97
	Moderate	6	3,87	3,87	14,84
	Severe	7	4,52	4,52	19,35
	Slight	125	80,65	80,65	100,00
	Total	155	100,00	100,00	

Previous Injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	138	89,03	89,03	89,03
	Yes	17	10,97	10,97	100,00
	Total	155	100,00	100,00	

Mechanism of Injury (Overuse / Trauma)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Overuse	41	26,45	26,45	26,45
	Trauma	114	73,55	73,55	100,00
	Total	155	100,00	100,00	

Injury Occurence (Training / Match)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Training	71	45,81	45,81	45,81
	Match	84	54,19	54,19	100,00
	Total	155	100,00	100,00	

Type of Surface

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Natural Grass	90	58,06	58,06	58,06
	3GAT	57	36,77	36,77	94,84
	2GAT	3	1,94	1,94	96,77
	Running Track	1	0,65	0,65	97,42
	Gym	4	2,58	2,58	100,00
	Total	155	100,00	100,00	

Type of Injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Concussion with or without loss of consciousness	1	0,65	0,65	0,65
	Abrasion	10	6,45	6,45	7,10
	Laceration	2	1,29	1,29	8,39
	Other injury	1	0,65	0,65	9,03
	Fracture	4	2,58	2,58	11,61
	Other bone injury	9	5,81	5,81	17,42
	Sprain / Ligament injury	20	12,90	12,90	30,32
	Muscle rupture / strain / tear / cramps	35	22,58	22,58	52,90
	Tendon injury / rupture / tendinosis / bursitis	4	2,58	2,58	55,48
	Haematoma / Contusion / Bruise	69	44,52	44,52	100,00
	Total	155	100,00	100,00	

Mechanism of Injury (Contact / Noncontact)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	52	33,55	33,55	33,55
	Yes, with another player	78	50,32	50,32	83,87
	Yes, with the ball	5	3,23	3,23	87,10
	Yes, with other object (3GAT - Sliding)	20	12,90	12,90	100,00
	Total	155	100,00	100,00	

Foul Play (No / Yes)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		71	45,81	45,81	45,81
	No	66	42,58	42,58	88,39
	Yes, free kick / penalty	18	11,61	11,61	100,00
	Total	155	100,00	100,00	

Foul Play (Injured player / Opponent)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		137	88,39	88,39	88,39
	Opponent	18	11,61	11,61	100,00
	Total	155	100,00	100,00	

Statistics

		Injury Severity (Days of Absence)	Injury Severity (Missed Sessions)	Time since Previous Injury (days)
N	Valid	30	30	3
	Missing	0	0	27
Mean		24,57	25,13	20,00
Median		4,00	4,50	19,00
Std. Deviation		38,67	41,73	9,54
Range		165	180	19
Minimum		1	1	11
Maximum		166	181	30
Sum		737	754	60

Injured Body Part

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Head / Face	3	10,00	10,00	10,00
	Hip / Groin	1	3,33	3,33	13,33
	Thigh	9	30,00	30,00	43,33
	Knee	2	6,67	6,67	50,00
	Lower Leg / Achilles Tendon	3	10,00	10,00	60,00
	Ankle	6	20,00	20,00	80,00
	Foot / Toe	2	6,67	6,67	86,67
	Neck / Cervical Spine	1	3,33	3,33	90,00
	Low Back / Sacrum / Pelvis	3	10,00	10,00	100,00
	Total	30	100,00	100,00	

Injured Body Side

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not applicable	4	13,33	13,33	13,33
	Right	16	53,33	53,33	66,67
	Left	9	30,00	30,00	96,67
	Bilateral	1	3,33	3,33	100,00
	Total	30	100,00	100,00	

Injury Severity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Career ending	1	3,33	3,33	3,33
	Mild	2	6,67	6,67	10,00
	Minimal	14	46,67	46,67	56,67
	Moderate	6	20,00	20,00	76,67
	Severe	7	23,33	23,33	100,00
	Total	30	100,00	100,00	

Previous Injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	23	76,67	76,67	76,67
	Yes	7	23,33	23,33	100,00
	Total	30	100,00	100,00	

Mechanism of Injury (Overuse / Trauma)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Overuse	10	33,33	33,33	33,33
	Trauma	20	66,67	66,67	100,00
	Total	30	100,00	100,00	

Injury Occurence (Training / Match)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Training	13	43,33	43,33	43,33
	Match	17	56,67	56,67	100,00
	Total	30	100,00	100,00	

Type of Surface

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Natural Grass	19	63,33	63,33	63,33
	3GAT	10	33,33	33,33	96,67
	Running Track	1	3,33	3,33	100,00
	Total	30	100,00	100,00	

Type of Injury

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Concussion with or without loss of consciousness	1	3,33	3,33	3,33
	Fracture	4	13,33	13,33	16,67
	Other bone injury	3	10,00	10,00	26,67
	Sprain / Ligament injury	5	16,67	16,67	43,33
	Muscle rupture / strain / tear / cramps	7	23,33	23,33	66,67
	Tendon injury / rupture / tendinosis / bursitis	2	6,67	6,67	73,33
	Haematoma / Contusion / Bruise	8	26,67	26,67	100,00
	Total	30	100,00	100,00	

Mechanism of Injury (Contact / Noncontact)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	15	50,00	50,00	50,00
	Yes, with another player	13	43,33	43,33	93,33
	Yes, with other object (3GAT - Sliding)	2	6,67	6,67	100,00
	Total	30	100,00	100,00	

Foul Play (No / Yes)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		13	43,33	43,33	43,33
	No	14	46,67	46,67	90,00
	Yes, free kick / penalty	3	10,00	10,00	100,00
	Total	30	100,00	100,00	

Foul Play (Injured player / Opponent)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		27	90,00	90,00	90,00
	Opponent	3	10,00	10,00	100,00
	Total	30	100,00	100,00	

Injured Body Part * Type of Injury Crosstabulation

Count

		Type of Injury										
		Concussion with or without loss of consciousness	Abrasion	Laceration	Other injury	Fracture	Other bone injury	Sprain / Ligament injury	Muscle rupture / strain / tear / cramps	Tendon injury / rupture / tendinosis / bursitis	Haematoma / Contusion / Bruise	Total
Injured Body Part	Head / Face	1	0	0	0	2	0	0	0	0	0	3
	Wrist	0	0	0	0	0	0	0	0	0	2	2
	Hand / Finger / Thumb	0	0	0	0	0	0	5	0	0	0	5
	Hip / Groin	0	2	0	0	0	0	0	4	0	0	6
	Thigh	0	1	0	0	0	0	0	10	0	12	23
	Knee	0	5	2	0	0	0	1	0	3	17	28
	Lower Leg / Achilles Tendon	0	2	0	0	1	4	0	9	1	13	30
	Ankle	0	0	0	0	0	1	10	0	0	6	17
	Foot / Toe	0	0	0	0	1	0	2	0	0	8	11
	Neck / Cervical Spine	0	0	0	0	0	0	0	2	0	2	4
	Sternum / Ribs / Upper Back	0	0	0	0	0	0	1	1	0	1	3
	Abdomen	0	0	0	1	0	0	0	1	0	0	2
	Low Back / Sacrum / Pelvis	0	0	0	0	0	4	1	7	0	4	16
	Shoulder / Clavicula	0	0	0	0	0	0	0	1	0	4	5
Total		1	10	2	1	4	9	20	35	4	69	155

Type of Injury * Injured Body Side Crosstabulation

Count

		Injured Body Side				Total
		Not applicable	Right	Left	Bilateral	
Type of Injury	Concussion with or without loss of consciousness	1	0	0	0	1
	Abrasion	0	3	6	1	10
	Laceration	0	1	1	0	2
	Other injury	0	1	0	0	1
	Fracture	0	2	2	0	4
	Other bone injury	4	2	0	3	9
	Sprain / Ligament injury	0	11	9	0	20
	Muscle rupture / strain / tear / cramps	10	7	15	3	35
	Tendon injury / rupture / tendinosis / bursitis	0	1	1	2	4
	Haematoma / Contusion / Bruise	1	34	33	1	69
Total		16	62	67	10	155

Type of Injury * Injury Severity Crosstabulation

Count

		Injury Severity						Total
		Career ending	Mild	Minimal	Moderate	Severe	Slight	
Type of Injury	Concussion with or without loss of consciousness	0	0	0	0	1	0	1
	Abrasion	0	0	0	0	0	10	10
	Laceration	0	0	0	0	0	2	2
	Other injury	0	0	0	0	0	1	1
	Fracture	1	0	0	0	3	0	4
	Other bone injury	0	0	1	1	1	6	9
	Sprain / Ligament injury	0	0	4	1	0	15	20
	Muscle rupture / strain / tear / cramps	0	1	2	2	2	28	35
	Tendon injury / rupture / tendinosis / bursitis	0	0	1	1	0	2	4
	Haematoma / Contusion / Bruise	0	1	6	1	0	61	69
Total		1	2	14	6	7	125	155

Type of Injury * Mechanism of Injury (Overuse / Trauma) Crosstabulation

Count

		Mechanism of Injury (Overuse / Trauma)		
		Overuse	Trauma	Total
Type of Injury	Concussion with or without loss of consciousness	0	1	1
	Abrasion	0	10	10
	Laceration	0	2	2
	Other injury	1	0	1
	Fracture	0	4	4
	Other bone injury	8	1	9
	Sprain / Ligament injury	1	19	20
	Muscle rupture / strain / tear / cramps	29	6	35
	Tendon injury / rupture / tendinosis / bursitis	2	2	4
	Haematoma / Contusion / Bruise	0	69	69
Total		41	114	155

Type of Injury * Injury Occurence (Training / Match) Crosstabulation

Count

		Injury Occurence (Training / Match)		
		Training	Match	Total
Type of Injury	Concussion with or without loss of consciousness	1	0	1
	Abrasion	4	6	10
	Laceration	1	1	2
	Other injury	1	0	1
	Fracture	3	1	4
	Other bone injury	2	7	9
	Sprain / Ligament injury	13	7	20
	Muscle rupture / strain / tear / cramps	20	15	35
	Tendon injury / rupture / tendinosis / bursitis	3	1	4
	Haematoma / Contusion / Bruise	23	46	69
Total		71	84	155

Type of Injury * Type of Surface Crosstabulation

Count

		Type of Surface					Total
		Natural Grass	3GAT	2GAT	Running Track	Gym	
Type of Injury	Concussion with or without loss of consciousness	1	0	0	0	0	1
	Abrasion	3	7	0	0	0	10
	Laceration	1	1	0	0	0	2
	Other injury	1	0	0	0	0	1
	Fracture	4	0	0	0	0	4
	Other bone injury	2	5	2	0	0	9
	Sprain / Ligament injury	13	6	0	0	1	20
	Muscle rupture / strain / tear / cramps	18	15	0	0	2	35
	Tendon injury / rupture / tendinosis / bursitis	2	0	0	1	1	4
	Haematoma / Contusion / Bruise	45	23	1	0	0	69
Total		90	57	3	1	4	155

Type of Injury * Mechanism of Injury (Contact / Noncontact) Crosstabulation

Count

		Mechanism of Injury (Contact / Noncontact)				Total
		No	Yes, with another player	Yes, with the ball	Yes, with other object (3GAT - Sliding)	
Type of Injury	Concussion with or without loss of consciousness	0	1	0	0	1
	Abrasion	0	3	0	7	10
	Laceration	0	1	0	1	2
	Other injury	1	0	0	0	1
	Fracture	1	3	0	0	4
	Other bone injury	8	0	0	1	9
	Sprain / Ligament injury	4	9	2	5	20
	Muscle rupture / strain / tear / cramps	33	2	0	0	35
	Tendon injury / rupture / tendinosis / bursitis	4	0	0	0	4
	Haematoma / Contusion / Bruise	1	59	3	6	69
Total		52	78	5	20	155

Type of Injury * Injured Body Part Crosstabulation

Count

		Injured Body Part									
		Head / Face	Hip / Groin	Thigh	Knee	Lower Leg / Achilles Tendon	Ankle	Foot / Toe	Neck / Cervical Spine	Low Back / Sacrum / Pelvis	Total
Type of Injury	Concussion with or without loss of consciousness	1	0	0	0	0	0	0	0	0	1
	Fracture	2	0	0	0	1	0	1	0	0	4
	Other bone injury	0	0	0	0	0	0	0	0	3	3
	Sprain / Ligament injury	0	0	0	0	0	5	0	0	0	5
	Muscle rupture / strain / tear / cramps	0	1	5	0	1	0	0	0	0	7
	Tendon injury / rupture / tendinosis / bursitis	0	0	0	2	0	0	0	0	0	2
	Haematoma / Contusion / Bruise	0	0	4	0	1	1	1	1	0	8
Total		3	1	9	2	3	6	2	1	3	30

Type of Injury * Injured Body Side Crosstabulation

Count

		Injured Body Side				
		Not applicable	Right	Left	Bilateral	Total
Type of Injury	Concussion with or without loss of consciousness	1	0	0	0	1
	Fracture	0	2	2	0	4
	Other bone injury	3	0	0	0	3
	Sprain / Ligament injury	0	2	3	0	5
	Muscle rupture / strain / tear / cramps	0	4	3	0	7
	Tendon injury / rupture / tendinosis / bursitis	0	1	0	1	2
	Haematoma / Contusion / Bruise	0	7	1	0	8
Total		4	16	9	1	30

Type of Injury * Injury Severity Crosstabulation

Count

		Injury Severity					
		Career ending	Mild	Minimal	Moderate	Severe	Total
Type of Injury	Concussion with or without loss of consciousness	0	0	0	0	1	1
	Fracture	1	0	0	0	3	4
	Other bone injury	0	0	1	1	1	3
	Sprain / Ligament injury	0	0	4	1	0	5
	Muscle rupture / strain / tear / cramps	0	1	2	2	2	7
	Tendon injury / rupture / tendinosis / bursitis	0	0	1	1	0	2
	Haematoma / Contusion / Bruise	0	1	6	1	0	8
Total		1	2	14	6	7	30

Type of Injury * Mechanism of Injury (Overuse / Trauma) Crosstabulation

Count

		Mechanism of Injury (Overuse / Trauma)		
		Overuse	Trauma	Total
Type of Injury	Concussion with or without loss of consciousness	0	1	1
	Fracture	0	4	4
	Other bone injury	3	0	3
	Sprain / Ligament injury	0	5	5
	Muscle rupture / strain / tear / cramps	6	1	7
	Tendon injury / rupture / tendinosis / bursitis	1	1	2
	Haematoma / Contusion / Bruise	0	8	8
Total		10	20	30

Type of Injury * Injury Occurence (Training / Match) Crosstabulation

Count

		Injury Occurence (Training / Match)		
		Training	Match	Total
Type of Injury	Concussion with or without loss of consciousness	1	0	1
	Fracture	3	1	4
	Other bone injury	2	1	3
	Sprain / Ligament injury	1	4	5
	Muscle rupture / strain / tear / cramps	3	4	7
	Tendon injury / rupture / tendinosis / bursitis	2	0	2
	Haematoma / Contusion / Bruise	1	7	8
Total		13	17	30

Type of Injury * Type of Surface Crosstabulation

Count

		Type of Surface			
		Natural Grass	3GAT	Running Track	Total
Type of Injury	Concussion with or without loss of consciousness	1	0	0	1
	Fracture	4	0	0	4
	Other bone injury	1	2	0	3
	Sprain / Ligament injury	1	4	0	5
	Muscle rupture / strain / tear / cramps	5	2	0	7
	Tendon injury / rupture / tendinosis / bursitis	1	0	1	2
	Haematoma / Contusion / Bruise	6	2	0	8
Total		19	10	1	30

Type of Injury * Mechanism of Injury (Contact / Noncontact) Crosstabulation

Count

		Mechanism of Injury (Contact / Noncontact)			
		No	Yes, with another player	Yes, with other object (3GAT - Sliding)	Total
Type of Injury	Concussion with or without loss of consciousness	0	1	0	1
	Fracture	1	3	0	4
	Other bone injury	3	0	0	3
	Sprain / Ligament injury	1	2	2	5
	Muscle rupture / strain / tear / cramps	7	0	0	7
	Tendon injury / rupture / tendinosis / bursitis	2	0	0	2
	Haematoma / Contusion / Bruise	1	7	0	8
Total		15	13	2	30

Injury Severity * Injured Body Part Crosstabulation

Count

		Injured Body Part									
		Head / Face	Hip / Groin	Thigh	Knee	Lower Leg / Achilles Tendon	Ankle	Foot / Toe	Neck / Cervical Spine	Low Back / Sacrum / Pelvis	Total
Injury Severity	Career ending	0	0	0	0	0	0	1	0	0	1
	Mild	0	0	2	0	0	0	0	0	0	2
	Minimal	0	1	3	1	2	4	1	1	1	14
	Moderate	0	0	2	1	0	2	0	0	1	6
	Severe	3	0	2	0	1	0	0	0	1	7
Total		3	1	9	2	3	6	2	1	3	30

Injury Severity * Injured Body Side Crosstabulation

Count

		Injured Body Side				
		Not applicable	Right	Left	Bilateral	Total
Injury Severity	Career ending	0	1	0	0	1
	Mild	0	2	0	0	2
	Minimal	1	8	5	0	14
	Moderate	1	3	1	1	6
	Severe	2	2	3	0	7
Total		4	16	9	1	30

Injury Severity * Mechanism of Injury (Overuse / Trauma) Crosstabulation

Count

		Mechanism of Injury (Overuse / Trauma)		Total
		Overuse	Trauma	
Injury Severity	Career ending	0	1	1
	Mild	1	1	2
	Minimal	3	11	14
	Moderate	3	3	6
	Severe	3	4	7
Total		10	20	30

Injury Severity * Injury Occurence (Training / Match) Crosstabulation

Count

		Injury Occurence (Training / Match)		Total
		Training	Match	
Injury Severity	Career ending	1	0	1
	Mild	0	2	2
	Minimal	5	9	14
	Moderate	3	3	6
	Severe	4	3	7
Total		13	17	30

Injury Severity * Type of Surface Crosstabulation

Count

		Type of Surface			Total
		Natural Grass	3GAT	Running Track	
Injury Severity	Career ending	1	0	0	1
	Mild	2	0	0	2
	Minimal	7	7	0	14
	Moderate	3	2	1	6
	Severe	6	1	0	7
Total		19	10	1	30

Injury Severity * Mechanism of Injury (Contact / Noncontact) Crosstabulation

Count

		Mechanism of Injury (Contact / Noncontact)			Total
		No	Yes, with another player	Yes, with other object (3GAT - Sliding)	
Injury Severity	Career ending	1	0	0	1
	Mild	1	1	0	2
	Minimal	5	7	2	14
	Moderate	5	1	0	6
	Severe	3	4	0	7
Total		15	13	2	30

Injured Body Part * Injury Severity Crosstabulation

Count

		Injury Severity						Total
		Career ending	Mild	Minimal	Moderate	Severe	Slight	
Injured Body Part	Head / Face	0	0	0	0	3	0	3
	Wrist	0	0	0	0	0	2	2
	Hand / Finger / Thumb	0	0	0	0	0	5	5
	Hip / Groin	0	0	1	0	0	5	6
	Thigh	0	2	3	2	2	14	23
	Knee	0	0	1	1	0	26	28
	Lower Leg / Achilles Tendon	0	0	2	0	1	27	30
	Ankle	0	0	4	2	0	11	17
	Foot / Toe	1	0	1	0	0	9	11
	Neck / Cervical Spine	0	0	1	0	0	3	4
	Sternum / Ribs / Upper Back	0	0	0	0	0	3	3
	Abdomen	0	0	0	0	0	2	2
	Low Back / Sacrum / Pelvis	0	0	1	1	1	13	16
	Shoulder / Clavicula	0	0	0	0	0	5	5
Total		1	2	14	6	7	125	155

Injury Severity * Injured Body Side Crosstabulation

Count

		Injured Body Side				Total
		Not applicable	Right	Left	Bilateral	
Injury Severity	Career ending	0	1	0	0	1
	Mild	0	2	0	0	2
	Minimal	1	8	5	0	14
	Moderate	1	3	1	1	6
	Severe	2	2	3	0	7
	Slight	12	46	58	9	125
Total		16	62	67	10	155

Injury Severity * Mechanism of Injury (Overuse / Trauma) Crosstabulation

Count

		Mechanism of Injury (Overuse / Trauma)		Total
		Overuse	Trauma	
Injury Severity	Career ending	0	1	1
	Mild	1	1	2
	Minimal	3	11	14
	Moderate	3	3	6
	Severe	3	4	7
	Slight	31	94	125
Total		41	114	155

Injury Severity * Injury Occurence (Training / Match) Crosstabulation

Count

		Injury Occurence (Training / Match)		
		Training	Match	Total
Injury Severity	Career ending	1	0	1
	Mild	0	2	2
	Minimal	5	9	14
	Moderate	3	3	6
	Severe	4	3	7
	Slight	58	67	125
Total		71	84	155

Injury Severity * Type of Surface Crosstabulation

Count

		Type of Surface					
		Natural Grass	3GAT	2GAT	Running Track	Gym	Total
Injury Severity	Career ending	1	0	0	0	0	1
	Mild	2	0	0	0	0	2
	Minimal	7	7	0	0	0	14
	Moderate	3	2	0	1	0	6
	Severe	6	1	0	0	0	7
	Slight	71	47	3	0	4	125
Total		90	57	3	1	4	155

Injury Severity * Mechanism of Injury (Contact / Noncontact) Crosstabulation

Count

		Mechanism of Injury (Contact / Noncontact)				
		No	Yes, with another player	Yes, with the ball	Yes, with other object (3GAT - Sliding)	Total
Injury Severity	Career ending	1	0	0	0	1
	Mild	1	1	0	0	2
	Minimal	5	7	0	2	14
	Moderate	5	1	0	0	6
	Severe	3	4	0	0	7
	Slight	37	65	5	18	125
Total		52	78	5	20	155